AG Contract No. KR02-1130TRN
ADOT ECS File: JPA 02-81
Project No. **H6223 01X**/ 02X / 03X / 04X / 05X / 99X
5-Year Item No. 25403-Various Locations
Research: ATLAS Research Center
Phase IV Program Administration

INTERAGENCY AGREEMENT

BETWEEN
THE DEPARTMENT OF TRANSPORTATION
AND
THE UNIVERSITY OF ARIZONA

THIS AGREEMENT is entered into 24 July, 2002, between agencies of the State of Arizona, to wit; the DEPARTMENT OF TRANSPORTATION (the "DOT") and the ARIZONA BOARD OF REGENTS, acting for and on behalf of UNIVERSITY OF ARIZONA, (the "University").

I. RECITALS

1. The DOT is empowered by Arizona Revised Statutes Section 28-401 and 28-334 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the DOT.

2. The University is empowered by Arizona Revised Statutes Section 15-1626 to enter into this agreement and has delegated to the undersigned authority to execute this agreement on behalf of the University.

3. The Transportation Efficiency Act - 21st Century (TEA21) has allocated federal funds in the amount of $793,615.00 to be administered by the State to continue support for the Center for Excellence in Advanced Traffic and Logistics Algorithms and Systems (ATLAS) at the University. The mission of the ATLAS Center is to perform advanced transportation technology, traffic and logistics management research. This agreement is to define the terms of the transfer of funds from the State to the University and the expenditure thereof.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

NO. 25392
Filed with the Secretary of State
Date Filed: 07/24/02
Betsey Bayless
Secretary of State
By: Libby V. Graeserwald

II. SCOPE OF WORK

1. The DOT will:

a. Appoint a Project coordinator to interface with the University relating to the ATLAS program research and various project development.

b. Provide the University with information and data as may be reasonably available to assist in project research and development.

c. Reimburse the University at 50% of allowable and allocable costs of work performed directly relating to the ATLAS program within forty-five days after receipt and approval of monthly invoices, in a total reimbursement amount not to exceed $793,615.00.

2. The University will:

a. Appoint a Project coordinator at the University (U of A) to interface with the DOT relating to the ATLAS program research and various project development.

b. Accomplish the work generally in accordance with Exhibit A, which is attached hereto and made a part hereof, provide the DOT monthly, quarterly and final project reports and other deliverables as are defined in Exhibit A, and in the FHWA-ADOT Program proposal, (which is attached hereto as Exhibit B and made a part hereof) such reports will be accompanied by a summary of expenditures. Such reports will be in a format compliant with the FHWA as described in the University proposal, and provide copies of same to the DOT.

c No more often than monthly, invoice the DOT in the form of Exhibit C attached hereto, an amount not to exceed $793,615.00

III. MISCELLANEOUS PROVISIONS

1. Title to all documents, reports and other deliverables prepared by the University in performance of this agreement shall rest jointly with the federal government, the DOT and the University.

2. This agreement shall become effective upon signature by the parties hereto, and shall remain in force and effect until completion of said ATLAS II project and reimbursements; provided, however, that this agreement, may be cancelled at any time prior to the commencement of performance under this agreement, upon thirty (30) days written notice to the other party.

3. The parties agree to comply with all applicable state and federal laws, rules, regulations and executive orders governing procurement, equal employment opportunity, immigration, nondiscrimination and affirmative action.

4. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.

5. The provisions of Arizona Revised Statutes Section 35-214 are applicable to this contract

6. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

7. All notices or demands upon any party to this agreement relating to the agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

For Contracting:
Arizona Department of Transportation
Joint Project Administration
205 S. 17th Avenue - 616E
Phoenix, AZ 85007

Technical Only:
University of Arizona
Dr. Pitu Mirchandani
1127 E. North Campus Drive, Room 111
Tucson, AZ 85719

For Billing/Reimbursements:
Arizona Department of Transportation
Contract Accounting
205 S. 17th Avenue - 616E
Phoenix, AZ 85007

University of Arizona
Research & Contract Analysis
888 N. Euclid Avenue, Room 515
Tucson, AZ 85721

8. The parties recognize that performance by the U of A under this Agreement may be dependent upon the appropriation of funds by the U.S. Department of Transportation, Federal highway Administration. Should the government at any time fail to assign the necessary funds for such performance, the DOT or the U of A may cancel this agreement.

9. Should the work contemplated under this agreement be completed at a lower cost than the reimbursed amount, or for any other reason should any of these funds not be expended, a proportionate amount of the funds provided shall be reimbursed to the State.

N WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

STATE OF ARIZONA

THE ARIZONA BOARD OF REGENTS
acting for and on behalf of
THE UNIVERSITY OF ARIZONA

By LeeAnne T. Peters
LEE ANNE T. PETERS
Contract Officer
Office of Research and
Contract Analysis

6/28/02
(date)

DEPARTMENT OF TRANSPORTATION

By Debra L Brisk
DEBRA BRISK
Deputy Director

7/3/02
(date)

G:02-081-ATRC-U of A-ATLAS
25Jun2002

JPA 02-81

RESOLUTION

BE IT RESOLVED on this 13th day of June, 2002, that I, the undersigned VICTOR M. MENDEZ, as Director of the Arizona Department of Transportation, have determined that it is in the best interests of the State of Arizona that the Department of Transportation, acting by and through the Transportation Planning Division, to enter into an agreement with the University of Arizona for the allocation federal funds in the amount of $793,615.00 to be administered by the State to continue support for the Center for Excellence in Advanced Traffic and Logistics Algorithms and Systems (ATLAS) at the University. The mission of the ATLAS Center is to perform advanced transportation technology, traffic and logistics management research.

Therefore, authorization is hereby granted to draft said agreement which, upon completion, shall be submitted to the Transportation Planning Division Director for approval and execution.

MARY LYNN TISCHER, Division Director
Transportation Planning Division
for VICTOR M. MENDEZ, Director

JPA 02-81

APPROVAL OF THE UNIVERSITY OF ARIZONA ATTORNEY

I have reviewed the above referenced proposed interagency agreement, between the DEPARTMENT OF TRANSPORTATION, INTERMODAL TRANSPORTATION DIVISION and the UNIVERSITY OF ARIZONA, and declare this agreement to be in proper form and within the powers and authority granted to the University under the laws of the State of Arizona.

DATED this 28th day of June, 2002.

Attorney for the University of Arizona

doc#4

JANET NAPOLITANO
ATTORNEY GENERAL

STATE OF ARIZONA
OFFICE OF THE ATTORNEY GENERAL
TRANSPORTATION SECTION
1275 WEST WASHINGTON STREET, PHOENIX, AZ 85007-2926

TRN Main: (602) 542-1680
Direct: (602) 542-8855
Fax: (602) 542-3646

MAIN PHONE : (602) 542-1680
FACSIMILE : (602) 542-3646

INTERGOVERNMENTAL AGREEMENT DETERMINATION

A.G. Contract No. KR02-1130TRN, an agreement between public agencies, has been reviewed pursuant to A.R.S. § 11-952, as amended, by the undersigned Assistant Attorney General who has determined that it is in the proper form and is within the powers and authority granted to the State of Arizona.

No opinion is expressed as to the authority of the remaining parties, other than the State or its agencies, to enter into said agreement.

DATED July 15, 2002.

JANET NAPOLITANO
Attorney General

Susan E. Davis

SUSAN E. DAVIS
Assistant Attorney General
Transportation Section

SED:ggt

Enc.

748426

EXHIBIT A

ITS Partnership Agreement
Between
The Federal Highway Administration
And
The Arizona Department of Transportation

Project No. ITS-9904-(010)

ITS Partnership Agreement
between
The Federal Highway Administration
and
The Arizona Department of Transportation

Project No. ITS-9904(010)

The purpose of this agreement is to award a grant of Federal assistance to the State for specific Intelligent Transportation Systems (ITS) activities, and to maximize the involvement of the State and other project participants in the ITS program, as authorized by the Transportation Equity Act for the 21st Century (TEA-21), P.L. 105-178, Sections 5201-5213 (23 USC 307 note). The parties to this agreement are independent contracting parties, and nothing in this agreement shall be deemed to create a business partnership for purposes of sharing profits and losses.

1. **Federal ITS Funds:** By executing this Agreement, the Government agrees, in accordance with TEA-21 Section 5208(g)(1), to reimburse the State with *Federal ITS Deployment Program funds* for a maximum of 50 percent of the allowable costs incurred in the performance of work under this ITS Partnership Agreement. The State shall be reimbursed for allowable costs incurred in the performance of work under this agreement in an amount not to exceed $793,615.

   1.1 Maximum Federal Share: In accordance with TEA-21 Section 5208(f)(2), the maximum share of *all Federal funding* for this project is not to exceed 80 percent of the cost of the activity. Thus the Federal funds must be matched at a minimum 80/20 (Federal/non-Federal) ratio, resulting in a matching share valued at not less than $317,446. Reimbursement will follow regular Federal-aid billing and payment procedures in accordance with 23 C.F.R. Part 140.

   1.2 Matching Share: The State shall match the Federal funds with at least 20 percent of the allowable costs. The 20 percent matching share must be from non-federally derived funding sources and must consist of cash, substantial equipment contributions that are wholly utilized as an integral part of the project, or significant personnel services dedicated to the ITS Integration project for a substantial period. Such personnel costs are allowable only if not otherwise supported with Federal funds. The non-federally derived funding may come from State, local government, or private sector partners. No fee payable to a project partner shall be allowed as part of the matching share. This provision does not prohibit appropriate fee payments to vendors or others who provide goods or services to the project. It also does not prohibit business relationships with the private sector which result in revenues from the sale or provision of ITS products or services.

1.3 **Other Project Funding**: The State shall arrange for financing of the remaining costs of the project. The remaining costs may be funded from a variety of sources, including State or local government funds, private sector contributions and federally-supported projects directly associated with the proposed integration project.

2. **Goals and Objectives**: The State shall work to accomplish the following goals and objectives (where goals represent high-level descriptions of what the project will accomplish and objectives define specific actions that can be used as metrics for determining progress towards the goals).

ATLAS Phase IV Goal

The goal of ATLAS-ITS Phase IV is to develop, demonstrate and deploy systems that integrate traffic adaptive control technologies and learning strategies for intelligent transportation systems.

ATLAS OBJECTIVES

- To demonstrate and deploy estimation methods that utilize real-time detector data (and associated high-speed communication network) to predict link travel times and traffic route volumes.

- To integrate traffic and travel databases and demonstrate a state-of-the-art network planning and management model.

- To utilize learning algorithms and traffic adaptive strategies to implement self-adaptive signal control at a diamond interchange.

- To develop and deploy adaptive transit signal priority methods at critical intersections using GPS-based Automated Vehicle Location (AVL) systems on buses.

- To demonstrate a lane-departure warning system that enhances vehicle safety, which integrates differential GPS and GPS-based maps.

3. **Responsibilities of the State**: In conformance with approved Work Orders (See Section 10 below), the State shall perform or cause to be performed the following:
   a. Activities as described in the attached Work Plan (See Section 4)
   b. Ensure conformance with ITS Architecture and standards (See Sections 5 and 6)
   c. A local evaluation and a local evaluation report (See Section 7)
   d. Inclusion of the project in the metropolitan or Statewide Transportation Improvement Program, as applicable, and in State air quality implementation plans, as appropriate.

4. **Work Plan:** The State shall develop a Memorandum of Understanding (MOU) executed by the partnership organizations, an overall project Work Plan, schedule, and budget including the minimum 20 percent non-Federal match requirement, for approval by the Federal Highway Administration (FHWA) Division and/or Federal Transit Administration (FTA) Regional Office. The MOU, Work Plan, schedule, and budget shall become part of this signed agreement and attached as the last appendix, Appendix C.

[MOU, WORK PLAN, SCHEDULE, AND BUDGET ATTACHED TO AGREEMENT BY STATE AS APPENDIX C]

4.1 **Directory of Key Personnel:** The project shall include in the Work Plan a Directory of Key Personnel. The Directory shall include a list of names, business addresses, telephone numbers and e-mail addresses of key public and private company personnel working on the project. The Directory shall also include contact information for key personnel with the State and Federal government who are involved with the project.

5. **ITS Architecture Conformance:** The proposed integration project shall identify how ITS architecture development activities will be incorporated into the project. Regional ITS architecture requirements depend upon the existence of a regional ITS architecture and the designated funding level from this program. Project level ITS architecture requirements depend on the existence of a regional ITS architecture. Both regional ITS architectures and project level ITS architectures shall be based on a systems engineering analysis.

a. *If* a regional ITS architecture exists (or is currently under development), *then* (1) the proposed integration project shall identify which parts of the regional ITS architecture the proposed project will implement and (2) the project will be designed in accordance with the regional ITS architecture. The regional ITS architecture shall be updated, as necessary, to reflect the specifics of the proposed project.

b. *If* a regional ITS architecture does not exist (and is not currently under development) and the proposed project is to receive more than $300K in funding (after takedowns) from this program in FY01, *then* (1) a project level ITS architecture shall be developed and the project will be designed in accordance with the project level architecture and (2) the development of a regional ITS architecture shall be initiated within one year of obligation of funds. Funding from this program may be used for these project level and regional ITS architecture development activities. The National ITS Architecture shall be used as a resource in the development of the project level and regional ITS architecture.

c. *If* a regional ITS architecture does not exist and the project is to receive less than $300K in funding (after takedowns) from this program in FY01, *then* a project level ITS architecture shall be developed and the project will be designed in accordance with the project level ITS architecture. Initiation of regional ITS architecture

development activities is not required at this point but is strongly encouraged.

6. **Standards:** The State shall identify the applicable ITS standards and/or interoperability tests that are being considered or are expected to be specified in the project documentation. The proposed integration project shall identify how ITS standards will be incorporated into the project. First, the proposed integration project shall consider all appropriate Standards Development Organization (SDO) approved ITS Standards for use in the proposed project. Second, the proposed integration project shall identify the ITS standards that are applicable and will be considered in the project design. If an applicable ITS standard will not be considered, the proposed integration project shall provide justification as to why the standard will not be considered. Third, the proposed integration project shall describe the process that will be used to ensure that the considered standards will be incorporated in the project design, as appropriate.

7. **Local Evaluation Report:** A Local Evaluation Report shall include a documentation of the lessons learned in meeting project goals and objectives (see Section 2). The report shall address those key aspects of the project evaluated, and to the extent possible, assess impacts on the relevant outcome measures as discussed in the *TEA-21 Evaluation Guidelines*. In addition, the Local Evaluation Report package will also include documentation on (1) two or more of the evaluation products/activities identified in the program guidance and (2) the projects cost accounting data. The report will contain an executive summary.

   An ITS Integration Program self-evaluation progress system has been developed to assist the ITS Joint Program Office in tracking deliverables. The system is accessible via the World Wide Web at http://www.itsevaluation.net. Each Earmark project should access this web site to upload project deliverables, including the Local Evaluation Report and cost information, and project points of contact information.

8. **Participation in Evaluations and/or Standards Testing of National Interest:** Those Projects determined by the U.S. DOT ITS Joint Program Office (JPO) to be unique or nationally significant will cooperate with and participate in all phases of the Government's evaluation and/or standards testing program, from evaluation/testing planning to reporting of evaluation/testing results.

9. **ITS Deployment Tracking Surveys:** ITS Deployment Tracking Surveys must be completed, if not done so already, in applicable metropolitan areas.

10. **Project Descriptions:** A Project Description shall be the basis for quarterly reporting of the project status by the recipient and shall be used as the basis for the Work Orders detailed in Section 10.1. The project descriptions shall also be used to inform external project contacts about the status of the projects. The following information shall be included in each Project Description: Project number, Project title, Primary contact, Project objective, Task Description, Milestones, Dates and Budget. Each Project Description shall be submitted with the Work Order request.

10.1 **Work Orders:** Individual activities within the project Work Plan, and further defined by the Project Description, agreed to be performed by the State or caused to be performed by the State shall be incorporated in Work Orders. Each Work Order will specify the work and goals to be accomplished and the type and amount of assistance to be provided by the FHWA. Each Work Order must include the Project Description, completion dates for the work, and the signatures of the FHWA Division Administrator and an authorized representative of the State indicating acceptance of the Work Order prior to initiation of any work described therein. Issuance of a Work Order does not constitute a promise, either expressed or implied, that the FHWA will issue further Work Orders or provide additional assistance pursuant to this ITS Partnership Agreement. Continued funding will be dependent on the successful completion of ongoing tasks.

11. **Period of Performance:** The period of performance is as stated in the Work Orders, but shall not be longer than three years from the date of this agreement, unless the term is extended by the mutual agreement of the State and FHWA. A final Local Evaluation Report (see section 7 above) documenting lessons learned and how well the project met the defined goals and objectives shall be submitted within six (6) months from the date of completion of the final Work Order and shall constitute completion of the project. This report shall be submitted to FHWA Division and/or FTA Regional Office, as appropriate.

12. **U.S. DOT Participation:** The United States Department of Transportation (U.S. DOT) agencies shall be considered full participants in the project. As such, the U.S. DOT shall be provided the opportunity for membership on all management committees, subcommittees, working groups, task forces, and other such groups related to the project. The U.S. DOT will provide names, addresses, and phone numbers of DOT participants to the State Program Manager.

13. **Reporting Requirements:** Copies of all project reports, correspondence, meeting announcements, and other documents shall be supplied directly to the U.S. DOT Division office. The U.S. DOT Division office will provide names and addresses of specific contacts to receive these documents. All interim and final reports submitted to the U.S. DOT Division office shall be in both a hard copy as a reproducible and as microcomputer files. The hard copy shall be done on a laser printer with a resolution of at least 300 dpi.

    a. The following shall be supplied to the ITS Electronic Document Library (EDL):

        1. Submit final reports and executive summary, including self-evaluation, via email to itspubs@fhwa.dot.gov with a cc to susan.slye@fhwa.dot.gov.
        2. Also send 3 copies on individual floppy disks via postal mail to the Publications Distribution Manager (for statutory transmittal to NTIS):
           Publications Distribution Manager
           ITS Joint Program Office – HOIT
           U.S. Department of Transportation

Washington, DC 20590

3. Accompanying the report and evaluation must be an EDL profile sheet and NTIS form 1700.7, which can be downloaded from the EDL front page (www.its.dot.gov/itsweb/welcome.htm).
4. Electronic submission must be compliant with section 508 of the Americans with Disabilities Act. (The document must be accessible via keyboard.). Acceptable formats are HTML and Word. Mac formats are unacceptable.

b. Quarterly Progress Reports. This subparagraph identifies data elements to be submitted to the FHWA Division ITS Specialist on or before the 20th of the month following the end of the quarter being reported. These data elements are required to enable FHWA Division staff to update project data for in-progress State ITS projects every quarter. At a minimum, the quarterly report shall contain a concise report covering the following:

1. In the first reporting quarter, the Federal aid project number or contract number.

Thereafter, on a quarterly basis:

2. Revisions, as needed, to project contacts with associated organizations and telephone numbers.
3. Revisions to original estimated project completion dates. Project completion is defined as submission of the project report to FHWA. Adjusted dates should be accompanied by a brief explanatory remark describing the causes of schedule adjustments.
4. Revisions to original estimated cost values. Adjusted cost data should be accompanied by a brief explanatory remark describing the causes of cost adjustments.
5. Percent of funds expended.
6. Brief identification of milestones attained and/or significant events affecting the project.
7. As needed, a brief description of challenges encountered or anticipated having the potential for affecting project scope, creating institutional issues or presenting other significant considerations.

14. **Programmatic Changes:** Programmatic changes to the scope of the project may be made with prior approval of the U.S. DOT. These include, but are not limited to:

a. Any revision of the scope, goals or objectives of the consultant contract or related activities (regardless of whether there is an associated budget revision requiring prior approval).
b. Changes in key personnel, program manager, or prime contractor.
c. Substitution of sub-projects between program years.

15. **Intellectual Property:** Intellectual property consists of copyrights, patents, and any other form of intellectual property rights covering any data bases, software, inventions, training manuals, systems design or other proprietary information in any form or medium.

It is the policy of the FHWA to allow the non-Federal partners of an ITS Partnership Agreement to retain all intellectual property rights developed under this agreement with the following limitations:

a. Copyrights. The FHWA, as the contracting U.S. DOT agency, reserves a royalty-free, nonexclusive and irrevocable license to reproduce, publish or otherwise use, and to authorize others to use, for Federal Government purposes:

1. The copyright in any works developed under this agreement, or under a subgrant or contract under this agreement; and
2. Any rights of copyright to which the State, its subgrantee, or contractor purchases ownership with Federal financial assistance provided by this agreement.

b. Patents. Rights to inventions made under this agreement shall be determined in accordance with 37 C.F.R. Part 401. The standard patent rights clause at 37 C.F.R. §401.14, as modified below, is hereby incorporated by reference.

1. The terms "to be performed by a small business firm or domestic nonprofit organization" shall be deleted from paragraph (g)(1) of the clause;
2. paragraphs (g)(2) and (g)(3) of the clause shall be deleted; and
3. paragraph (1) of the clause, entitled "Communications" shall read as follows: "(1) Communications. All notifications required by this clause shall be submitted to the FHWA Division Office."

16. **Costs:** The State shall limit its progress claims and final claims to those costs incurred in accordance with this ITS Partnership Agreement and shall submit its final claim within ninety (90) days after the project is completed.

17. **Additional Requirements:** These ITS funds shall be used only in support of, or for research on, intelligent transportation systems and not for construction of buildings. The design and operation of this ITS project must be consistent with the National ITS Architecture and the purposes of section 5206(e) of TEA-21. This project shall contribute to the implementation of the ITS standards development work and shall promote interoperability of ITS systems among the States. The final rule regarding conformity with the National ITS Architecture was published January 8 in the *Federal Register* at 66 FR1446, and was effective April 8, 2001. Participation of small business concerns owned and controlled by socially and economically disadvantaged individuals is encouraged. The State shall comply with all applicable laws, regulations and the FHWA requirements, including, but not limited, to 49 C.F.R. Parts 18, 20, 21, 27, and 29, and the assurances in

OMB SF 424B attached hereto as Appendix A. These ITS funds shall be expended in compliance with the Buy America Act (41 U.S.C. 10a-10c).

18. **Certification Regarding Lobbying:** The State makes the certification regarding lobbying which is attached hereto as Appendix B.

19. **Termination:** The State shall notify FHWA immediately of any intent to terminate this ITS Partnership Agreement.

20. **Effective Date:** This ITS Partnership Agreement is effective upon execution by both parties.

State Department of Transportation

Title: Asst. State Engr.

Date 5/28/02

Federal Highway Administration

David S. Nelson

Division Administrator

Date 5-29-02

ASSURANCES - NON-CONSTRUCTION PROGRAMS

Note: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant I certify that the applicant:

1. Has the legal authority to apply for Federal assistance, and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project costs) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States, and if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§ 4728-4763) relating to prescribed standards for merit systems for programs funded under one of the nineteen statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§ 1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. § 794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§ 6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§ 523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. 290 dd-3 and 290 ee-3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. § 3601 et seq.), as amended, relating to non-discrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply with the provisions of the Hatch Act (5 U.S.C. §§ 1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§ 276a to 276a-7), the Copeland Act (40 U.S.C. § 276c and 18 U.S.C. §§ 874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§ 327-333), regarding labor standards for federally assisted construction subagreements.

10. Will Comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451 et seq.); (f) conformity of Federal actions to State (Clear Air) Implementation Plans under Section 176(c) of the Clear Air Act of 1955, as amended (42 U.S.C. § 7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended, (P.L. 93-523); and (h) protection of endangered species under the Endangered Species Act of 1973, as amended. (P.L. 93-205).

12. Wil comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§ 1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. 469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. 2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§ 4801 et seq.) which prohibits the use of lead based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act of 1984.

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations and ploicies governing this program

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	TITLE
[signature]	Assistant State Engineer
APPLICANT ORGANIZATION	DATE SUBMITTED
Arizona Department of Transportation	4/25/02

Appendix B

CERTIFICATION REGARDING LOBBYING

By execution of this ITS Partnership Agreement, the undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No Federal-appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an office or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any ITS Partnership Agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or ITS Partnership Agreement.

(2) If any funds other than Federal-appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an office or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or partnership agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and partnership agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31 U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

A:\SMPLAGMT.WPD

EXHIBIT B

APPLICATION FOR PARTICIPATION IN THE
FY01 ITS INTEGRATION COMPONENT
OF THE
ITS DEPLOYMENT PROGRAM

PROJECT DESCRIPTION

APPLICATION FOR PARTICIPATION IN THE FY01 ITS INTEGRATION COMPONENT of the ITS DEPLOYMENT PROGRAM

PROJECT DESCRIPTION

Project Identification Number:

Project Identification Name: ATLAS-ITS PHASE IV

Project Location: Arizona

FY01 Congressionally Designated Funding Amount: $ 793,615

Submitted by (Agency): The University of Arizona
(Date): February 28, 2001

Project Contact (Name): Dr. Pitu B. Mirchandani
(Organization): ATLAS Center
(Address): Old Engineering Building 20
The University of Arizona
Tucson, Arizona 85721
(Phone): 520-621 7284
(Fax): 520-621 6555
(e-mail): kris@sie.arizona.edu

TABLE OF CONTENTS

Executive Summary 3

Project Proposal 6

Technical Approach 7
1. Background 7
2. Project Description 8
3. Rural Projects 17
4. Infrastructure Components to Be Integrated 21
5. Integration Approach 22
6. Architecture 22
7. ITS Standards and Standards Testing 24
8. Evaluation of Benefits 25

Schedule 27
9. Start Date 27
10. Expected Completion Date 27
11. Milestones 27

Financial Plan 28
12. Non-Federally Derived Funding Sources 28
13. Other Funding Sources 29

Participating Agencies and Organizations 37
14. Project Participants and Roles and Responsibilities 37

ATLAS-ITS PHASE IV: INTEGRATION AND DEPLOYMENT OF REAL-TIME ADAPTIVE AND LEARNING STRATEGIES FOR INTELLIGENT TRANSPORTATION SYSTEMS.

EXECUTIVE SUMMARY

ITS infrastructure and environment in some Arizona cities and elsewhere in the USA has been significantly enhanced to enable the integration and deployment of new methods and technologies that have hitherto been neglected or set aside for future considerations. In many areas we now have a fiber-optic backbone that can carry large amounts of data and information, we have more powerful computational capabilities in the vehicles and on the roadside, the differential GPS signals that are available to the general public now have resolutions of a few centimeters, wireless technologies and communication infrastructure have widespread uses, and the technical know-how of the population has been considerably enhanced.

Arizona metropolitan areas and its many cities have significant ITS plans, and have either a well developed ITS Architecture or will have shortly. Also, Arizona has been involved in several ITS operational tests. The Arizona Department of Transportation (ADOT) is looked upon by ITS researchers, practitioners, firms and agencies as having a very forward vision for transportation in the 21st Century and as being very pro-active to make this vision come true.

Also, the University of Arizona, though its Center for Excellence in Advanced Traffic and Logistics Algorithms and Systems (ATLAS), has been involved with several ITS projects including operational testing of traffic adaptive signal control, research/development of innovative approaches to real-time prediction of traffic conditions, research/development of approaches for transit priority and highway-railway grade crossing, and development and demonstration of intelligent vehicle-highway systems.

Given the accommodating environment for integration and deployment of cutting edge ITS technologies and methods, this Integration Project -- referred to as ATLAS-ITS Phase IV -- will make use of elements of the available new ITS infrastructure to integrate and deploy such new technologies. In particular, the ATLAS teams will (a) deploy estimation methods that utilize real-time detector data (and associated high-speed communication network) to predict link travel times and traffic route volumes, (b) utilize learning algorithms and traffic adaptive strategies to implement self-adaptive signal control at a diamond interchange, (c) deploy GPS-based Automated Vehicle Location (AVL) systems on buses for transit signal priority at critical intersections, and (d) integrate differential GPS and GPS-based maps to provide lane-departure warning to enhance vehicle safety. The demonstration of the above integration efforts will be done at several locations in Arizona and with various private and public partners/collaborators. As such this Project is subdivided into the following five subprojects, numbered 4A, 4B, 4C, 4D, and 4E.

4A. *Tucson's ITS Diamond Interchange: Integration and deployment of a self-adaptive real-time traffic signal control strategy*

4B. *Tempe's ITS Public Transit Project: Integration and deployment of transit signal priority*

4C. *Deployment of an approach for real-time estimation of arterial travel times*

4D. *Implementation of a Combined Travel Forecasting Model for the Tucson Region*

4E. *Deployment of Digital Vehicle/Highway Technology for Safety Enhancement*

Project 4A is primarily an "Urban Traffic Management" project; it will integrate arterial traffic control with freeway management, using various detector and communication technologies. The portion from the Congressional Designated funding that will go towards this project will be approximately $ 204,000. This will be matched by $ 34,500 of local funds, by the University of Arizona for project management through the ATLAS Center and by the City of Tucson for video detection and other equipment. In addition, $ 200,000 for the design and implementation of ITS elements that were provided by the City of Tucson and Arizona's TIP is used as cost match for this project

Project 4B is a "Public Transportation" project that will integrate traffic signal control and transit management, utilizing a GPS-based Automatic Vehicle Locator (AVL) system and wire/wireless communication, to provide implement real-time bus priority at some critical intersections. The portion from the Congressional Designated funding that will go towards this project will be approximately $ 225,000. This will be matched by $ 230,000 of local funds: (i) by the University of Arizona for project management and research assistants through the ATLAS Center ($ 55,000) and (ii) by the City of Tempe for implementation of GPS-based AVL system for its buses, an accompanying transit management system, and release time of traffic and transit management personnel for this project (totaling $175,000).

Project 4E is primarily a "Rural ITS" project that will integrate automatic vehicle location based on high-precision GPS and intelligent vehicle technologies to provide lane departure safety warnings. Various in-vehicle sensors, including a differential GPS receiver, an inertial measuring unit (IMU), a camera and externally mounted radars will be integrated, and the resulting vehicle location will be calibrated along the way with "calibration points" having known precise GPS coordinates. The vehicle will issue a warning when it departs, or about to depart, the lane in which it is traveling. The portion from the Congressional Designated funding that will go towards this project will be approximately $ 203,500. This will be matched by $ 213,000 of local funds: (i) by the University of Arizona for project management and faculty release time through the ATLAS Center ($ 33,000) and (ii) by ITI Inc. and its Consortium for the implementation of accurate GPS-based maps for "Road to Zero Fatalities" program, for donation of a car, project management and operations (totaling $180,000).

In Project 4C detector and measurement technologies are integrated to provide travel times and speeds for applications in transportation planning and management. The portion from the Congressional Designated funding that will go towards this project will be approximately $ 105,000. This will be matched by $ 135,000 from: (i) local funds by the University of Arizona for project management, faculty release time and research assistants through the ATLAS Center (totaling $ 35,000), (ii) a grant from the Bureau of Transportation Statistics (of $ 50,000) and (iii) by the Maricopa County Department of Transportation (MCDOT) for further support (of $ 40,000).

In Project 4D traffic and travel databases will be integrated to implement Boyce's *Combined Model*[1], which combines trip distribution, mode choice and assignment steps in a practical way for large zone systems and networks. This model will be implemented in cooperation with the Transportation Planning Division of the Pima Association of Governments (PAG), which is responsible for the regional travel demand modeling in eastern Pima County. The portion from the Congressional Designated funding that will go towards this project will be $ 55,700. This will be matched by an equal amount of local funds; (i) by the University of Illinois for support for Dr. Boyce who will be assigned to the ATLAS Center for

[1] D.Boyce and H. Bar-Gera (2001), Validation of Urban Travel Forecasting Models Combining Origin-Destination, Mode and Route Choices, Working Paper, The University of Illinois, June 2001.

approximately 3 months (totaling $ 41,400), and (ii) by the University of Arizona for project management and personnel support through the ATLAS Center (totaling $ 14,300).

The total cost for the five subprojects is $ 1,651,406, of which $ 793,615 is Congressional Designated funding. At least 20% of the overall project cost ($317,446) will come from non-Federally derived funding local sources. The remaining $ 540,345will come from a variety of other funding including Federally supported sources. It should be noted that $ 203,529of the $ 793,615 Congressional Designated amount will go towards a project (Project 4E) that is predominately Rural ITS.

The overall program will be led by the ATLAS Center at the University of Arizona, and will have several partners/collaborators including the Arizona Department of Transportation, the City of Tucson, the City of Tempe, the Maricopa County Department of Transportation, Siemens-Gardner Transportation Systems, Intelligent Technologies International, Inc., Pima Association of Governments and few other traffic/transportation companies who will be subcontractors as specified in the project descriptions. The partners/collaborators on this ATLAS team have a proven record of cooperation. They have worked together on several traffic management projects. In addition, all of the project team members are committed to improving traffic conditions, enhancing the benefits of mobility, and decreasing traffic congestion and its detrimental impacts. Appropriate public agencies, interest groups and stakeholders will be involved in the integration and deployment activities.

The Proposed project will comply with the applicable regional ITS Architecture and Plans. The Pima Association of Governments (PAG), the Maricopa Association of Governments (MAG) as well as Maricopa County Department of Transportation (MCDOT), thorough *AzTech*^{TM} Model Deployment Project, have extensive involvement in the development of ITS Plan and Architecture in the metropolitan areas within their jurisdiction. In fact, currently, under the leadership of PAG, a comprehensive ITS Plan/Architecture is being defined for Pima County transportation that will provide guidelines for all future ITS projects (e.g., Project 4A). Similar efforts are underway at MAG and MCDOT. Thus a regional ITS architecture exists or is being developed.

Since this is an Integration Project, consisting of few subprojects, each having several components that are to be integrated, the ITS Standards that apply are integration interfaces and not for the components themselves. With regard to the components that are being integrated in the subprojects (with the exception of Project 4E), either they already conform with set ITS Standards or applicable ITS Standards are still being debated upon. For example, NTCIP Standards are nearly set but most traffic management systems have still to adopt them. Fortunately, our partner Siemens-Gardner Transportation Systems utilizes a system in the City of Tucson that comes closest to satisfying the NTCIP standards and hence our controller-center messages will conform to NTCIP.

In Project 4E, the National ITS Architecture's component for Automated Highways and Intelligent Vehicles apply. Significant effort on the development of a common architecture has been expended by federal agencies, automobile manufacturers and trucking companies, but no clear "winner" has been established that most, if not all, stakeholders agree upon. Even the area of data structure standards for map databases is being currently debated by standards organizations (IEEE, ITS America, and others). To the extent possible, Project 4E will follow established regional ITS architecture and will utilize a system that comes closest to the "standard" for which there is significant consensus.

Each of the projects described in the proposal will be evaluated, either by ATLAS personnel (self-evaluations) and its Technical Advisory Committee or by third parties. These evaluations will address key aspects such as

- Beneficial and detrimental impacts to transportation management and traffic flow
- System and subsystem performance
- Consistency with the National ITS Architecture
- Acceptance by the users
- Institutional issues and concerns

PROJECT PROPOSAL

ATLAS-ITS PHASE IV: INTEGRATION AND DEPLOYMENT OF REAL-TIME ADAPTIVE AND LEARNING STRATEGIES FOR INTELLIGENT TRANSPORTATION SYSTEMS.

TECHNICAL APPROACH

1. Background

In the last few years the University of Arizona, though its Center for Excellence in Advanced Traffic and Logistics Algorithms and Systems (ATLAS), has been involved with several ITS projects including operational testing of traffic adaptive signal control, research/development of innovative approaches to real-time prediction of traffic conditions, research/development of approaches for transit priority and highway-railway grade crossing, and development and demonstration of intelligent vehicle-highway systems. The mission of the ATLAS Center is to perform research, development, and integration of advanced methods and technologies in traffic management and logistics management, and to educate and perform technology transfer in these areas. The Integration Project defined in this document is central to the ATLAS Mission. Being a Research-University-based center, ATLAS has the mandate to develop, integrate, and deploy cutting edge technologies and methods; and as such, this type of Integration Project differs from that deployed by state and local agencies, either directly or with assistance of traditional consulting firms. In fact, ATLAS has unique capabilities to perform the project described below.

To provide a backdrop and discuss needs and motivation for the proposed Project, let us consider recent ITS history. ITS infrastructure and environment in some Arizona cities and elsewhere in the USA has been significantly enhanced to enable the integration and deployment of new methods and technologies that have hitherto been neglected or set aside for future considerations. In many areas we now have a fiber-optic backbone that can carry large amounts of data and information, we have more powerful computational capabilities in the vehicles and on the roadside, the differential GPS signals that are available to the general public now have resolutions of a few centimeters, wireless technologies and communication infrastructure have widespread uses, and the technical know-how of the population has been considerably enhanced.

Arizona metropolitan areas and its many cities have significant ITS plans, and have either a well developed ITS Architecture or will have shortly. Also, Arizona has been involved in several ITS operational tests. The Arizona Department of Transportation (ADOT) is looked upon by ITS researchers, practitioners, firms and agencies as having a very forward vision for transportation in the 21st Century and as being very pro-active to make this vision come true.

Given the accommodating environment for integration and deployment of cutting edge ITS technologies and methods, this phase of the ATLAS Program -- referred to as ATLAS-ITS Phase IV -- will make use of elements of the available new ITS infrastructure to integrate and deploy such new technologies. In particular, the ATLAS teams will (a) deploy estimation methods that utilize real-time detector data (and associated high-speed communication network) to predict link travel times and traffic route volumes, (b) utilize learning algorithms and traffic adaptive strategies to implement self-adaptive signal control at a diamond interchange, (c) deploy GPS-based Automated Vehicle Location (AVL) systems on buses for transit signal priority at critical intersections, and (d) integrate differential GPS and GPS-based maps to

provide lane-departure warning to enhance vehicle safety. The demonstration of the above integration efforts will be done at several locations in Arizona and with various private and public partners/collaborators. As such this Project is subdivided into five subprojects, numbered 4A, 4B, 4C, 4D, and 4E; Project 4E may be considered predominately rural.

Thus, the technical project descriptions discussed in the next two sections consist of the following five subprojects:

4A. *Tucson's ITS Diamond Interchange: Integration and deployment of a self-adaptive real-time traffic signal control strategy*

4B. *Tempe's ITS Public Transit Project: Integration and deployment of transit signal priority*

4C. *Deployment of an approach for real-time estimation of arterial travel times*

4D. *Implementation of a Combined Travel Forecasting Model for the Tucson Region*

4E. *Deployment of Digital Vehicle/Highway Technology for Safety Enhancement*

The overall program will be led by the ATLAS Center at the University of Arizona, and will have several partners/collaborators including the Arizona Department of Transportation, the City of Tucson, the City of Tempe, the Maricopa County Department of Transportation, Pima Association of Governments, Siemens-Gardner Transportation Systems, Intelligent Technologies International, Inc., and few other traffic/transportation companies who will be subcontractors as specified in the project descriptions.

2. Project Descriptions

2.1 Project 4A: Tucson's ITS Diamond Interchange: Integration and deployment of a self-adaptive real-time traffic signal control strategy

The City of Tucson and ADOT are designing the I-19/ Valencia Interchange. Besides the actual rebuilding of the infrastructure and the widening of Valencia, they are interested in incorporating ITS elements at this Diamond Interchange based on the Regional ITS Plan and Architecture. The ITS plan includes CCTV, fiber conduits across the Valencia structure (which will be above the I-19 lanes), and variable message signs. It is estimated that the cost for designing and implementing ITS elements will be approximately $500,000. The City is also interested in having a traffic adaptive element being integrated and deployed within a traffic management system to provide real-time traffic adaptive signal control.

Over the last several years, the University of Arizona has developed the *RHODES* adaptive traffic control system [Mirchandani and Head, 2001][2]. It is currently developing a new version, referred to as *SMART-RHODES*, where parameters such as turning ratios and queue discharge rates are derived from the traffic detected over the last several cycles. This project will be to deploy *SMART-RHODES* for this "ITS Diamond Interchange". Briefly, *SMART-RHODES* (a) gathers data from the detectors at the interchange and from the detectors upstream (at the ramps and from the upstream intersections on the arterial), (b)

[2] P.B. Mirchandani and K.L. Head, "A Real-Time Traffic Signal Control System: Architecture, Algorithms, and Analysis", *Transportation Research Part C*

phase timings of the upstream traffic signals, (3) integrates this data, and (4) set phase timings for the traffic signals at the interchange to maximize a performance measure given by jurisdiction.

In the construction of the interchange, local detector data, including ramp stop-bar detectors and upstream ramp passage detectors, will be available to the controller at the interchange.

It is envisioned that upstream passage detectors at 12th Avenue and Valencia, as well as upstream from about 1/2 mile west of the Interchange, will be communicated via wireless (using CDPD Protocol). This project will include the purchasing of the Advanced Traffic Controller (ATC) for the interchange as well as the wireless modems, transmitters and receivers. The City will install this equipment on Valencia.

This project comprises of 9 tasks, which are described below.

Task A1: Project Management

ADOT and the City of Tucson will manage the overall design of the ITS Diamond Interchange. ATLAS personnel will manage the *SMART-RHODES* enhancement of the Diamond Interchange. ATLAS personnel and researchers, its subcontractors and its collaborators/partners will meet regularly to review status and track schedule for the subproject to integrate and deploy *SMART-RHODES* at the interchange.

Task A2: System Design

ATLAS personnel will develop a detailed design of the integration (of the *RHODES* algorithms, traffic management software, communication system, detectors, and controllers), deployment, and field testing of *SMART-RHODES*. Included in this task will be a review of configuration (detectors, communications, controllers, traffic management interfaces, etc.). Siemens-Gardner Transportation Systems will assist ATLAS personnel on this task

Task A3: Simulation Modeling

ATLAS personnel will collect traffic data for the Tucson Diamond Interchange (referred to as TDI from hereon) and develop a CORSIM simulation model for the TDI for laboratory investigation. The simulation model will be calibrated and validated based on the available data.

Task A4: SMART-RHODES Simulation

ATLAS personnel will develop the *SMART-RHODES* files for the TDI and investigate performance of *SMART-RHODES* using the simulation models.

Task A5: Integration of SMART-RHODES within ATC

An ATC has its own operating system and traffic control software, which operate the signals as done currently (in semi-actuated or fully actuated with time-of-day parameters). Inclusion of *SMART-RHODES* as an option to control the TDI requires that *SMART-RHODES* be integrated with the software and the operating system residing in the controller, including the sending and receiving of data and command to/from the *SMART-RHODES* code. Siemens-Gardner Transportation Systems will assist ATLAS personnel on this task.

Task A6: Field Integration

As is normally the case, the controller at the interchange resides in a cabinet (in this case a TS2 cabinet) and communicates with Tucson Operations Center (TOC), via a telephone line, where the status of the controller can be monitored. It is envisioned that the design of the interchange control will include the receiving of additional detector data from upstream points on Valencia (besides the local detector data already provided at the cabinet). It is currently envisioned that the upstream data will be communicated to the controller via wireless (using CDPD Protocol). Thus, field integration includes the integration of *SMART-RHODES*/ATC within the TS2 cabinet at the TDI, implementation and testing of communication from upstream detectors, and implementation of any necessary status/command signals between the ATC and the TOC. Furthermore, the system will be integrated so that the TOC will be able to obtain traffic data from the interchange to monitor its performance and parameters of interest that *SMART-RHODES* may be estimating in real-time (for example turning ratios and travel times). Siemens-Gardner Transportation Systems will assist ATLAS personnel on this task.

Task A7: Field Bench Test

ATLAS personnel will run *SMART-RHODES* at the TDI in a shadow mode and fine-tune necessary fixed parameters.

Task A8: Field Test

The City of Tucson and ATLAS personnel will conduct a field test.

Task A9: Field Evaluation

Independent third parties will evaluate the field-test results. If not some party assigned by FHWA or ADOT, Catalina Engineering and/or ITT Industries will perform the evaluation.

The portion from the Congressional Designated funding that will go towards this project will be approximately $ 204,000. This will be matched by $ 34,500 of local funds, by the University of Arizona for project management through the ATLAS Center and by the City of Tucson for video detection and other equipment. In addition, $200,000 (of the $500,000) for the design and implementation of ITS elements that were provided by the City of Tucson and Arizona's TIP are used as cost match for this project.

Professor Pitu Mirchandani, Director of the ATLAS Center, will lead the project team. The other partners/collaborators on this project will be the City of Tucson, ADOT, Siemens-Gardner Transportation Systems, Catalina Engineering and ITT Industries.

2.2 Project 4B: Tempe's ITS Public Transit Project: Integration and deployment of transit signal priority

The City of Tempe is purchasing a set of buses for local commuter service between Arizona State University and surrounding neighborhoods. The buses will be traveling on University Drive through several congested intersections. Tempe wishes to implement ITS elements in the design and operations of these buses.

Tempe is planning to have the buses be equipped with an Automatic Vehicle Locator (AVL) system and implement real-time transit management functionality. In addition, Tempe would like to include *RHODES*-based bus priority at some critical intersections.

Hence, the goal of this ATLAS IV subproject is to provide bus priority (when necessary) at some intersections for the new "ITS Buses" for the planned circulator transit service. The type of priority implemented will be active network priority using *RHODES* logic [Mirchandani et al., 2001][3]. Here upstream locations notify local intersections on the schedule status of buses (late or early) and the passenger counts. *RHODES*-based transit priority considers this information and explicitly optimizes phase durations to minimize an objective such as average passenger delay or average travel times.

Preliminary design for the project calls for equipping the buses with a GPS system and a reporting/monitoring system at the Tempe TOC that updates the position of each bus approximately every 10 seconds. Again, it is envisioned that a wireless communication system, using CDPD protocol, will be implemented for this purpose. This information will be provided to a "*RHODES Transit Priority System*", residing within the Tempe TOC, where the schedule of the buses is available and the current position is compared with the scheduled position. If any bus is unduly late, then a signal will be sent to the *RHODES* traffic control system, which computes a "bus weight", that is considered in the *RHODES* bus-priority logic in its phase duration computations.

This project comprises of 11 tasks, which are described below.

Task B1: Project Management

The City of Tempe will manage the overall ITS Public Transit Project. ATLAS personnel will manage the integration and deployment of *RHODES*-based transit signal priority. ATLAS personnel and researchers, its subcontractors and its collaborators/partners will meet regularly to review status and track schedule for the subproject to integrate and deploy transit signal priority.

Task B2: System Design

ATLAS personnel will develop a detailed design of the integration, deployment, and field-testing of the *RHODES* Bus Priority Logic. Include in this task will be a review of configuration (detectors, communications, controllers, transit management interfaces, etc.). Two types of design architectures will be considered. In one type, the current Computran Traffic Management System will be enhanced to except phase durations from the *RHODES* Transit Priority System and subsequently actuate force-offs and extensions on the affected traffic signals to implement these phase durations. The other alternative will be to develop a subsystem that communicates the "*transit requests for priority service*" directly to ATCs at the affected intersections, which in turn will compute and actuate the phase duration commands obtained from the local *RHODES* logic. Siemens-Gardner Transportation Systems will assist ATLAS personnel on this design development

Task B3: Implementation of a Transit Monitoring System

[3] P.B. Mirchandani, K.L. Head, Anna Knyazyan, and Wenji Wu, "An Approach Towards the Integration of Bus Priority and Traffic Adaptive Signal Control", *Computer-Aided Scheduling of Public Transportation* (eds. S. Vos and J.R. Daduna), Springer, Berlin, 2001.

The City of Tempe will equip the buses with an appropriate GPS system and a transit reporting/monitoring system. Currently, it is envisioned that a technology developed by Advanced Digital Systems, Inc. (ADS) will be used for that purpose. ADS has already equipped buses with such a system in the Phoenix area in the *AzTech*^{TM} Model Deployment Project. Here the GPS location is communicated via wireless, using CPDP protocol, to the TOC. A map is available which provides the bus' location with respect to the street it is traveling on.

Task B4: Integration of RHODES with Transit Monitoring

ATLAS personnel will integrate the transit monitoring system the *RHODES* Transit Priority System. Siemens-Gardner Transportation Systems will assist ATLAS personnel on this task

Task B5: Development of RHODES Priority Logic

ATLAS researchers will develop *RHODES*-type prediction/control algorithms for extrapolating bus locations and comparing them with scheduled bus locations and generating predicted "*transit requests for priority service*" at the intersections.

Task B6: Simulation Modeling

ATLAS personnel will collect traffic data for the affected Tempe network and surroundings and develop a CORSIM simulation model for laboratory investigations. The simulation model will be calibrated and validated based on the available data.

Task B7: RHODES Bus-priority Simulation

ATLAS personnel will develop the *RHODES* files for the intersections where the priority logic will be implemented. They will evaluate performance of *RHODES* Bus Priority using the simulation models, and the results will be documented.

Task B8: Integration of RHODES Bus-priority with Traffic Management

When there is a "*transit requests for priority service*" at an intersection, a call may have to go to the intersection to implement a new phase duration. Effectively, this means that force-offs and extensions need to be actuated. Two design alternatives (see Task B2) are possible: one is through a centralized system where phase durations are computed at the TOC an subsequently actuated through the traffic management system, and the other is where only "bus weights" are provided for local *RHODES* algorithms at the intersection, which subsequently computes its own phase durations. Siemens-Gardner Transportation Systems and/or Computran will assist ATLAS personnel on this task.

Task B9: Field Bench Test

ATLAS personnel will run *RHODES* Bus-Priority in a shadow mode and fine-tune necessary fixed parameters.

Task B10: Field Test

The City of Tempe and ATLAS personnel will conduct a field test.

Task B11: Field Evaluation

An independent third party will evaluate the field-test results. If not some party assigned by FHWA or ADOT, TASK Engineering will perform the evaluation.

The portion from the Congressional Designated funding that will go towards this project will be approximately $ 225,000. This will be matched by $ 230,000 of local funds: (i) by the University of Arizona for project management and research assistants through the ATLAS Center ($ 55,000) and (ii) by the City of Tempe for implementation of GPS-based AVL system for its buses, an accompanying transit management system, and release time of traffic and transit management personnel for this project (totaling $175,000).

The project team will be co-led by Professor Pitu Mirchandani, Director of the ATLAS Center and Jim Decker of the City of Tempe. The other partners/collaborators on this project will be Siemens-Gardner Transportation Systems, Computran Inc., ADS Inc. and TASK Engineering.

2.3 Project 4C: Deployment of an approach for real-time estimation of arterial travel times

Accurate real-time estimation of arterial travel times has significant importance in traffic management. The objective of the project is to apply an innovative statistical analysis technique for travel time estimation where: (1) travel time estimation is performed using data with a resolution of a few seconds and (2) the effect of volume and location of vehicle entrances and exits is considered.

Travel time estimation for freeways using loop detector data is well developed. In general, these results are based on a simple stochastic model for freeway travel, in which vehicles that arrive at an upstream detector during a given time interval have a common probability distribution of travel time to a downstream detector. This model assumes (1) there are no vehicles entering or exiting the roadway between detectors, and (2) the probability distribution of travel time is invariant within a given time or distance. However, for urban arterials, traffic flow is significantly affected by vehicles entering and exiting the roadway. Furthermore, for real-time applications, higher resolution data are required, with a time interval of a few seconds. Although it is feasible to obtain loop detector data every second, there is a lack of an accurate traffic model that can fully use these data for arterial travel time estimation.

The proposed project is composed of four tasks, model selection, parameter estimation, model refinement, and model deployment/evaluation. Brief details of each task are discussed below.

Task C1: Model Selection

The Project Team has postulated two models for estimating link travel times. In one approach, a set of detectors is used to identify platoons of vehicles. Downstream of this is another set that identifies platoons. Using a maximum likelihood matching approach the upstream set is matched with the downstream set. Once the matching is performed, it is straightforward to estimate prevailing travel times for each of the platoons.

The other approach assumes that there is an entering stream U_1 at one of n given locations d_{1i} (i=1,...,n); and an exiting stream U_2 at one of the m given locations d_{2i}, (i=1,...,m). The magnitude of each stream and the position of the entry and exit points are random variables. The impact of the disturbance streams

on arterial flow is considered using different probability distribution functions f_k (k=1, 2, 3), corresponding to: (i) no vehicle access (k=1), (ii) vehicle entering (k=2), and (iii) vehicle exiting (k=3).

The above two approaches will be evaluated for deployment purposes, in terms of accuracy and computational times.

Task C2: Model Parameter Estimation

As in any statistical estimation procedure, the underlying models include parameters that need to be estimated to better predict travel times. In this task the models will be calibrated via these parameters and subsequently validated by comparison with an alternative method to obtain travel times, e.g., travel probes.

Task C3: Model Refinement

Further effort may be necessary to extract non-random components to improve the model and estimation accuracy. For example, to consider the uncertainties of the model structure (f_1, f_2, f_3) due to the disturbance streams and the roadway capacity, additional indices may be defined and used in the residual noise evaluation to refine the model structure.

Task C4: Model Deployment and Evaluation

The proposed model will be deployed for two different data sets in Arizona. The Maricopa County Department of Transportation has one-second detector data for selected arterial segments in Phoenix. Also, the ATLAS Research Center at the University of Arizona has a unique facility where real-time detector data is collected every second by video detectors on a major arterial in Tucson. For both data sets, the accuracy of travel time estimates will be assessed by using video camera data, where a manual matching of the vehicle images between the upstream point and the downstream point will be used to obtain the actual travel time of vehicles. This will serve both to refine the proposed modeling techniques and to validate the deployed model.

For the Tucson site, the estimated travel times will be used for two purposes. The first will be to provide travel times to the City of Tucson Transportation Department. They could use it for performance monitoring and for providing it to traveler information systems. (Currently, a web-server is being developed that gives travel time estimates, and also a private-sector third party provides traffic conditions to the public.) The second purpose will be to use it in the traffic adaptive system, *RHODES*, which is being implemented at the Tucson site. *RHODES* requires travel time estimates and currently some default approximations are used. Both these purposes will require the integration of the algorithms with Tucson's traffic control systems.

The portion from the Congressional Designated funding that will go towards this project will be approximately $ 105,000. This will be matched by $ 135,000 from: (i) local funds by the University of Arizona for project management, faculty release time and research assistants through the ATLAS Center (totaling $ 35,000), (ii) a grant from the Bureau of Transportation Statistics (of $ 50,000) and (iii) by the Maricopa County Department of Transportation (MCDOT) for further support (of $ 40,000).

The project team will led by a recent member of the ATLAS Center, Assistant Professor. Judy Jin, who has a 13 year research experience and more than 20 published papers in applied multivariate statistics,

signal processing, process modeling and analysis. The research team also includes Dr. Pitu Mirchandani from the Systems and Industrial Engineering Department, Dr. Mark Hickman from the Department of Civil Engineering and Engineering Mechanics. Also in the project team will be Mr. David Wolfson, who is a senior analyst for MCDOT with over 20 years of experience in traffic modeling and analysis. He will collaborate with the ATLAS team and in his effort, of up to 100 hours over the project duration (a further in-kind contribution by MCDOT), he will provide traffic data as well as advice on the usage of the models for MCDOT's planning and management functions.

2.4 Project 4D: Implementation of a Combined Travel Forecasting Model for the Tucson Region

Travel forecasts by class of traveler (or trip purpose) and modes are needed to evaluate future transportation and urban development plans. Traditionally, such forecasts have been prepared using the sequential, or four-step, procedure, a time-consuming and awkward approach with inherent limitations for the comparison of alternative plans. Research recently completed by Dr. Boyce at University of Illinois at Chicago has shown that an alternative approach that combines trip distribution, mode choice and assignment steps is practical to apply for large zone systems and networks. Boyce refers to this as the *Combined Model*[4].

The proposed effort will implement the *Combined Model* for the Tucson Region. This model will be implemented in cooperation with the Transportation Planning Division of the Pima Association of Governments (PAG), which is responsible for the regional travel demand modeling in eastern Pima County. In addition, the model will be applied to future planning scenarios derived from the PAG 2025 Regional Transportation Plan, and its utility from the viewpoint of planners will be investigated.

To complete this project, four tasks are envisioned. First, the necessary baseline and forecast year data must be assembled. Second, using the *Combined Model*, travel characteristics for the base year and the forecast horizon will be generated. In the third task, these characteristics will be compared with the existing PAG modeling efforts, and the utility of the *Combined Model* will be evaluated. Finally, the experience gained from this implementation of the *Combined Model* will be summarized in appropriate documentation. These four tasks are outlined below.

Task D1: Data Assembly

The following data or forecasts are needed to implement the model:

1. a detailed zone system for the region;
2. a road network, with capacities and free flow travel times, for the region;
3. zone-to-zone travel times and fares for the regional transit system;
4. generalized cost (impedance) coefficients by trip purpose for auto and transit travel used in the present model;
5. auto occupancy by trip purpose for the region;
6. cost sensitivity coefficients by trip purpose used in the trip distribution and mode choice models;

[4] D.Boyce and H. Bar-Gera (2001), Validation of Urban Travel Forecasting Models Combining Origi-Destination, Mode and Route Choices, Working Paper, The University of Illinois, June 2001.

7. zonal trip origins and destinations (productions and attractions) by trip purpose for the morning and afternoon peak periods;
8. one or more truck trip tables by type of truck.

At this time, the University of Arizona has obtained these items from PAG for the base year 2000 and for a forecast year of 2025, corresponding to the latest forecast year in PAG's Long–Range Regional Transportation Plan (RTP).

Task D2: Model Implementation

Using the data listed above (particularly items 1-7) for the base year (2000), the proposed *Combined Model* will be implemented and compared with past calibration efforts at PAG. The model will be solved for the morning and afternoon peak, and various summary measures will be computed as follows:

1. vehicle miles of travel by trip purpose;
2. average trip length by mode and purpose (miles);
3. vehicle hours of travel by trip purpose;
4. average travel time by mode and purpose (minutes);
5. average operating cost by auto and fare by transit by trip purpose;
6. generalized cost by mode and purpose;
7. proportion of trips by transit by purpose;
8. space-mean-speed.

These summary measures will be used to compare the model to existing PAG calibration data, and to other model estimates for the base year (2000). Using these results, the model will be "tuned" to reproduce the observed summary measures for the region. Because time will be limited, a full calibration of the model will not be undertaken.

In addition to the base year (2000), we will also generate forecast travel estimates for the current PAG RTP forecast year (2025). The same performance measures (1–8 above) will be generated for 2025, using the network characteristics forecast for the PAG region in 2025.

Task D3: Model Comparison and Evaluation

In this step, we will compare the results from the *Combined Model* to the existing PAG forecasts. This will compare the summary measures identified above, examining similarities and differences from the *Combined Model* with those of the PAG model. In addition, screenline traffic volumes will also be compared. These results will be discussed with PAG TPD staff.

Task D4: Documentation

A description of the implemented model will be prepared. A paper describing the use of the model by the Tucson region planners, and their reactions to the *Combined Model* will be prepared.

An objective of the effort is to put the model into the hands of planners involved in forecasting future travel for the Tucson region. Subsequently the project team would like to determine how planners react

to the attributes of forecasts that the team believes can only be achieved presently with such a model. These include:

1. higher convergence of traffic assignments;
2. improved consistency between road network travel times and distances on the one hand, and travel times and distances used in the trip distribution and mode choice models on the other; in other words, the model is solved with full feedback in one execution of the computer code; and
3. improved turn-around in obtaining results, basically an overnight computer job.

PAG will integrate the *Combined Model* with its databases and utilize its results for regional planning purposes. In addition, the model will be evaluated directly by PAG and will be illustrated to the City of Tucson, particularly in using short-term and long-term archived ITS data for estimating arterial travel times and to identify possible operational improvements.

The portion from the Congressional Designated funding that will go towards this project will be $ 55,694. This will be matched by an equal amount of local funds; (i) by the University of Illinois for support for Dr. Boyce who will be assigned to the ATLAS Center for approximately 3 months (totaling $ 41,401), and (ii) by the University of Arizona for project management and personnel support through the ATLAS Center (totaling $ 14,323).

This project will be led by Professor David Boyce from the Civil Engineering Department of the University of Illinois at Chicago who will be spending part of his sabbatical during the 2001–2002 academic year at the University of Arizona. UA's Professors Mark Hickman (from the Department of Civil Engineering and Engineering Mechanics) and Pitu Mirchandani (from the Department of Systems and Industrial Engineering), and a research assistant will assist Dr. Boyce.

3. Rural Projects

The fifth project (4E) described below is predominately a rural project because safety on rural highway driving will be impacted the most. In spite of the widespread use of seatbelts and airbags, more than 40,000 people are killed annually in traffic accidents. According to Government forecasts, this number will gradually increase with increasing vehicle usage and slow highway construction. The vehicle/highway process has failed. To combat fatalities, David Breed and his ITI Inc. has proposed the concept of "Road to Zero Fatalities" (RtZF©) that has shifted the vehicle/highway paradigm from "projects" to "process". The basic idea is to prevent the traffic accidents based on the exact vehicle location obtained through a combination of differential global positioning system (DGPS), inertial guidance, and strategically placed infrastructure that periodically allows the vehicle to know its exact location. However, it will take many years of developing and testing before the complete RtZF© or similar system can be implemented.

3.1 Project 4E: Deployment of Digital Vehicle/Highway Technology for Safety Enhancement

The main object of the proposed project is to develop, test and deploy a safety warning system using high precision digital road maps and a combination of various vehicle status sensory techniques, without or with a minimum requirement of additional road infrastructures. The basic technical concept is that if a vehicle knows within centimeters where it is and where the roadway is to a similar precision, many highway accidents can be prevented by warning drivers of possible hazardous situations using the state of

the art vehicle sensory and geo-location technology. Furthermore, if the vehicle also knows where all other vehicles in its vicinity are through vehicle to vehicle communication, most highway fatalities can be eliminated. However, this project will focus on the warning aspect only.

To accomplish our goal, the proposed project is composed of the following nine tasks:

E.1. Project Management
E.2. Design of High Precision and Real-time Accessible GIS-Databases
E.3. Procedures of Data Collection and Fusion for GIS-Databases
E.4. Construction and Implementation of Calibration Bases
E.5. GIS-Database Population for Selected Road Segments
E.6. Selection and Validation of Vehicle Status Sensors
E.7. Integration and Fusion of In-Vehicle Sensors and GPS/IMU Sensors
E.8. Development of a Prototype Safety Warning System
E.9. Test, Implementation, and Deployment of Prototype Safety Warning System

Each of these tasks is elaborated below.

Task E1: Project Management

ITI Inc. will manage the overall "Digital Vehicle/Highway Technology" Project. ATLAS personnel will manage the integration and deployment of a prototype safety warning system. ATLAS personnel and researchers and its collaborators/partners will meet regularly to review status and track schedule for the subproject to integrate and deploy the prototype safety warning system.

Task E2: Design of High Precision and Real-time Accessible GIS-Databases

General-purpose GIS (geographical information system) databases alone will not be suitable for the proposed project due to requirements for high accuracy of position and real-time accessibility. A cache-type structure, similar to the one used widely in computers for efficient real-time memory management, will be utilized to establish a high precision and real-time accessible GIS-database. The proposed GIS database will consist of two parts: a small real-time executable digital map and a large off-line GIS database. The small real-time digital map is generated from the large off-line GIS database according to the current vehicle location, velocity and warning specification provided. The small digital map contains only the sufficient information that can be manipulated in real-time to warn the driver of any specified possible driving hazard with respect to its currently location and velocity on the road.

A commercial GIS-Databases (such as ArcView or MapInfo) will be selected and evaluated for constructing the large off-line GIS database, while the small real-time digital map will be developed and tested by the project team.

Task E3: Procedures of Data Collection and Fusion for GIS-Databases

Procedures for collecting and verifying data for the GIS database will be established. First, the procedure for data collection using a single sensor will be created, and then the algorithm for data fusion with multiple sensors will be developed, and finally, the steps for verifying data integrity with multiple sensors will be established.

The project will start this task with a computer simulation program to verifying the proposed procedure, algorithm, and steps. It will then be carried out for a small road segment for testing, and modification, and improvement.

Task E4: Construction and Implementation of Calibration Bases

Barcode type calibration bases will be established along highway that would allow a vehicle to read and calibrate its position, orientation, and velocity in real-time with respect to a local highway coordinate system, and then transform to a global highway coordinate system. Calibration bases can also provide the preview road/lane information for specified distances. The acquired position, orientation, and velocity will be used to correct and calibrate other information provided by vehicle sensors periodically for high accuracy and reliability. They can also be used in cases of sensor failures and/or out of range such as under bridges or in tunnels.

Initially, the project team will paint barcodes on the road and develop a laser-based barcode reading device for a vehicle to read those barcodes. (Quite likely another approach for bar coding such as magnetic stripes or laser reflectors will be used in applications when the road is covered with snow.) Algorithms will be designed and tested for fast, accurate and reliable barcode signal processes. The method of determining the number of calibration bases and distribution along a given segment of a highway will also be investigated in this task.

Task E5: GIS-Database Population for Selected Road Segments

In this task, the project team will apply the methods and procedures established in Tasks E2-E4 to create a high precision and real-time accessible GIS database (it will be referred as the Digital Road Map in this proposal) for a selected road segment in Arizona. Most likely the segment will be on the I-10 corridor between Phoenix and Tucson.

The position accuracy and access time are the two main requirements for the Digital Road Map. Those two requirements must be realistic yet useful in implementing safety warning systems. The selected segment provides a test bed for the results established in Tasks E2-E4. Based on the result of this task, the project team may have to change and/or modify Tasks E2-E4 methods and procedures.

Task E6: Selection and Validation of Vehicle Status Sensors

The project will evaluate the use of calibration bases and four types of sensors for collecting vehicle status information such as position, orientation, and velocity. The four types of sensors are:

a) in-vehicle sensors (an encoder and a high precision semiconductor potentiometer) for measuring orientation and speed of a vehicle;
b) video cameras for identifying the relative position of a vehicle with respect to road edges or lines (an auto-tracking sensor);
c) inertia measurement units (IMUs) for finding the relative orientation and acceleration of a vehicle; and
d) GPS or DGPS receivers for obtaining the absolute position of a vehicle.

The first three type sensors provide continuous information, while GPS and calibration bases offer discrete information at a given time period and distance. The continuous and discrete information will be

used individually and jointly to find the vehicle status information. The discrete information will be used to calibrate the continuous information periodically, while the continuous information to interpolate the discrete information between the two acquisition points. Other fusion strategies will also be investigated.

We believe that at least one continuous type and one discrete type sensor must be used in this project. Currently only in-vehicle sensors and camera are available. The project team will acquire one of each sensor, evaluate their performance and then select the appropriate ones for the project based on the accuracy, real-time accessibility, and reliability consideration. Of course, the cost of those sensors will also be a factor.

Task E7: Integration and Fusion of In-Vehicle Sensors and GPS/IMU Sensors

It is clear that a GPS receiver will be one of the sensors selected for this project. Another sensor that provides continuous information must be used to augment the GPS information. Otherwise one will not be able to find the vehicle orientation and location accurately and reliably, especially for high speed driving as well as between two GPS calibration points. This will make it impossible to incorporate vehicle size into consideration when issuing warning to drivers. Therefore, we will develop and test algorithms that will integrate the GPS information, barcode type calibration bases, in-vehicle sensors and/or IMU sensors.

The basic strategy is to use in-vehicle and/or IMU signals to interpolate the GPS information between GPS calibration points, and to reset in-vehicle and/or IMU signals with GPS at each calibration base point. This will offer us robust position, orientation, and speed information with high precision and reliability. Other more sophisticated fusion algorithms will also be investigated in the project.

Task E8: Development of a Prototype Safety Warning System

Based on the Digital Road Map, vehicle status sensors, and vehicle locating algorithms developed in the previous tasks, a prototype safety warning system will be constructed. The safety warning system will provide the following two functions:

a) Warning the driver passively when a vehicle is crossing the road sideline (i.e., creating electronic rumbling strips) or a lane without turn signal indicator being "ON" (i.e., creating electronic lanes); and
b) Warning the driver proactively the possible hazardous situation based on the current vehicle position, orientation, speed and road condition.

The second warning function will need a sophisticated decision-making system to identify the hazardous driving situation based on vehicle status and road condition. In this project, the team will construct a rudimentary one for proof of concept and demonstration.

Note that to for the safety warning system to be operational, the project team will need to expend significant effort for integrating the Digital Road Map, barcode type calibration bases, vehicle status sensors (including GPS locators), vehicle locating algorithms, and the safety warning hardware/software.

Task E9: Test, Implementation, and Deployment of Prototype Safety Warning System

The safety warning system developed in the proposed project will be installed on the project vehicle, tested and deployed on selected road segments in Arizona. This task will be divided into two stages, which will focus on operational and precision aspects respectively. In the first stage operational aspects will be defined, using low accuracy sensors and without the differential GPS infrastructure. In this stage, the project team will test and evaluate the safety warning system hardware and software with low-grade sensors, and establish a correct operational procedure. In the second stage, the team will focus on the accuracy aspect -- to provide meaningful warning information using high precision sensors with the differential GPS infrastructure (the infrastructure will be provided by a third party, as part of cost sharing from ITI Inc., most likely from the OmniStar Inc.).

The portion from the Congressional Designated funding that will go towards this project will be approximately $ 203,500. This will be matched by $ 213,000 of local funds: (i) by the University of Arizona for project management and faculty release time through the ATLAS Center ($ 33,000) and (ii) by ITI Inc., and its consortium for the implementation of accurate GPS-based maps for "Road to Zero Fatalities" program, for donation of a car, project management and operations (totaling $180,000).

Professor Fei-Yue Wang who is a member of ATLAS Center will lead the proposed project. Prof. Wang has a 19-year professional experience, being involved on more than 30 projects and having published over 100 papers in mechanical, electrical, electronic, computer, transportation, information and systems engineering journals and magazines. Professor Pitu Mirchandani and several UA research assistants will also be on the Project Team.

The other partners/collaborators on this project will be ADOT, ITI Inc., GM OnStar, SRI International, Lambda Technology International and OmniStar.

4. Infrastructure Components to Be Integrated

Since the overall project contains several subprojects, integrated and deployed at several locations in Arizona, there are different agencies for different subprojects for the same component. For example "Traffic Signal Control" component will be the responsibility of the City of Tucson for Project 4A, and City of Tempe for Project 4B. So, in the table below designations in the parenthesis indicate the project for which the agency is responsible.

A. Traffic Signal Control
    1. Transportation Department, City of Tucson (Project 4A)
    2. Transportation Department, City of Tempe (Project 4B)
B. Freeway Management
    1. ADOT FMS, (Project 4A)
    2. ADOT FMS, (Project 4E)
C. Transit Management
    1. Public Transit, Transportation Department, City of Tempe (Project 4B)
D. Incident Management
    1.NA
E. Electronic Fare Payment
    1.NA
F. Electronic Toll Collection
    1.NA
G. Highway-Rail Intersection Control

1. NA

H. Emergency Services Management

1. NA

I. Paratransit and Demand-Responsive Transit

1. Public Transit, City of Tempe (Project 4B)

J. Regional Multi-Modal Traveler Information Services

1.NA

K. Other ITS Systems

K1. Traffic Management/Planning

1.ATLAS Center and Tucson DOT (Project 4A)

2.ATLAS Center and Tucson DOT (Project 4C)

3. ATLAS Center and Pima Association of Governments (Project 4D)

K2. Digital Maps (for ITS Applications)

K3. Advanced Vehicle Safety

1.ATLAS Center and ITI Inc. (Project 4E)

K4. Global Positioning System

1. ATLAS Center and ITI Inc. (Project 4E)

In other words, in:

Project 4A. Elements of Traffic Control, Traffic Management, and Freeway Management will be integrated

Project 4B. Elements of Traffic Control, Traffic Management, and Transit Management will be integrated

Project 4C. Elements of Traffic Control and Traffic Management/Planning will be integrated

Project 4D. Databases and elements of Traffic Management/Planning will be integrated

Project 4E. This is predominately a rural ITS Project. Elements of Traffic Management and Vehicle Systems (including digital maps, barcode type calibration bases, vehicle sensors, vehicle locator system, and global positioning system) will be integrated.

5. Integration Approach

Since this is an Integration Project, consisting of several subprojects, each having different elements for integration, the integration approach for each subproject is discussed in Sections 2 and 3 of the document which describe each of the five subprojects in detail.

6. Architecture

ATLAS-ITS PHASE IV Project will follow the Architecture Approach specified in Section 3.2 of the guidelines. Below we describe current ITS Plan and Architecture and how the various subprojects described here fit with this plan and architecture.

The Pima Association of Governments (PAG), the Maricopa Association of Governments (MAG) as well as Maricopa County Department of Transportation (MCDOT), thorough *AzTech*^{TM} Model Deployment Project, have extensive involvement in the development of ITS Plan and Architecture in the metropolitan areas within their jurisdiction. In fact, currently, under the leadership of PAG, a comprehensive ITS Plan/Architecture is being defined for Pima County transportation that will provide guidelines for all future ITS projects (e.g., Project 4A). Similar efforts are underway at MAG and MCDOT. Thus, the following holds:

X A regional ITS architecture exists or is being developed.

In Project 4A, the ITS Architecture for Pima County will apply. Currently, the traffic management systems in Pima County are being upgraded and are conforming to this ITS Architecture. ITS elements described in the project are in the ITS Plan. When the project is approved the architecture will be updated to explicitly include the elements integrated and deployed.

In Project 4B, the ITS Architecture for Maricopa County will apply. Already, the *AzTech*^{TM} Model Deployment Project includes elements such as GPS-based AVL that uses wireless communication to report the vehicles position. Currently, MCDOT is considering the standardization of traffic management systems in Maricopa County so that (a) they conform to ITS Architecture and Standards, and (b) the various traffic operations centers within Maricopa freely communicate with each other. Hence, if the City of Tempe follows the Maricopa ITS Architecture and conforms to the attendant standards, then surely the ATLAS Project 4B will also conform. It should be remarked that the City of Tempe was an active participant in *AzTech*^{TM} Model Deployment Project. When Project 4B is approved, the architecture will be updated to explicitly include the elements integrated and deployed.

In Projects 4C, real-time traffic measurements as well as other sources of data are fused to estimate arterial travel times and speeds. As such, the results of this project are methods to analyze, store and display data and information, for ITS and other applications. Although the database and communication elements of this project will follow applicable ITS standards, the project does not effect or affected by the overall regional ITS Architectures.

In Projects 4D, regional transportation planing databases will be integrated within the *Combined Model*. The results of this project will be evaluated directly by PAG and will be illustrated to the City of Tucson, particularly in using short-term and long-term archived ITS data for estimating arterial travel times and to identify possible operational improvements. The databases for this project will follow applicable ITS standards. The results of the project may enhance the overall regional ITS Architecture if the planning model discovers new ITS elements not now considered (e.g., congestion pricing).

In Project 4E, the National ITS Architecture's component for Automated Highways and Intelligent Vehicles apply. Significant effort on the development of a common architecture has been expended by federal agencies, automobile manufacturers and trucking companies, but no clear "winner" has been established that most, if not all, stakeholders agree upon. Even the area of standards for map databases is being debated, as this document is being written. The regional architectures are necessarily sketchy in the area of intelligent vehicles, vehicle safety, and automated highways. Still it is envisioned that future automobiles and highways will be more "intelligent" and will need some sort of ITS infrastructure/architecture. To the extent possible, Project 4E will follow established regional ITS architecture. When Project 4E is approved, effected architectures will be updated to explicitly include the elements integrated and deployed.

7. ITS Standards and Standards Testing

The proposed project agrees to follow the ITS Standards Testing approach included in Section 3.3 of the Guidance.

Since this is an Integration Project, consisting of few subprojects, each having several components that are to be integrated, the ITS Standards that apply are integration interfaces and not for the components themselves. With regard to the components that are being integrated in the subprojects (with the exception of Project 4E), either they already conform with set ITS Standards or applicable ITS Standards are still being debated upon. For example, NTCIP Standards are nearly set but most traffic management systems have still to adopt them. Fortunately, our partner Siemens-Gardner Transportation Systems utilizes a system in the City of Tucson that comes closest to satisfying the NTCIP standards and hence our controller-center messages will conform to NTCIP. Note that the RHODES traffic adaptive signal control logic requires messages similar to that for actuated control plus more; all these will conform to applicable NTCIP standards. In any case,

In Project 4A, applicable standards are for (1) communication between controller-center, (2) object definitions for advanced traffic controllers, which includes object definitions for actuated signals (as well as traditional MUTCD standards needed for all controllers), (3) object definitions for CCTV, and (4) communication between detectors and controllers. Current traffic management system adopted by City of Tucson, Siemens-Gardner's *ICONS*, follows the standards specified for (1) – (4). There is an element in Project 4A where standards are still not fully defined, and that is for the wireless communication. We will be using wireless (with CDPD Protocol) between the upstream detectors and the controllers. We envision that by the time we incorporate the wireless equipment in the project, the vendors supplying this equipment will adhere to whatever ITS Standard is in place at that time, if any.

In Project 4B, the applicable standards are for (1) communication between controller-center, (2) communication between center's traffic management system and "*RHODES Transit Priority System*", (3) vehicle location referencing, and (4) wireless communication between the buses' GPS/AVL System detectors and controllers. With regard to (1) and (2), the City of Tempe, Computran, and Siemens-Gardner will assure that whatever ITS communication standards are applicable, and deployable in the City during the project duration, they will be utilized in Project 4B. With regards to (3), we will examine the current database standards and make sure that our "*RHODES Transit Priority System*" adheres to it. With regard to (4), as for Project 4A, standards are still not fully defined for the wireless communication (with CDPD Protocol) between the buses and TOC. Again, we envision that by the time we incorporate the wireless equipment in the project, the vendors supplying this equipment will adhere to whatever ITS Standard is in place at that time, if any.

In Projects 4C and 4D, real-time traffic measurements as well as other sources of data are fused to estimate arterial travel times and other measures of traffic. As such, the results of these projects are methods to analyze, store and display data and information, for ITS and other applications, database and communication elements of these projects will follow applicable ITS standards.

In Project 4E, the applicable standards are for map databases which allow for high precision GPS information within a GIS system. Data structure for such database is being currently debated by standards organizations (IEEE, ITS America, and others). We will examine the current database options and their applicability to the development of the lane-warning system and will utilize a system that comes closest to the "standard" for which there is significant consensus.

This project agrees to follow applicable ITS Standards. As discussed in beginning of the section, ITS standards applicable in this Integration project depend on the component being integrated. The components either are using well-defined standards or the standards are still being debated.

The ATLAS team agrees to cooperate with the analysis of the project as a potential test site for the US DOT sponsored ITS Standards Testing Program, provided that (a) there is no cost impact for ATLAS, and (b) no cost impact for its partners and subcontracts. If an ATLAS site is selected and there is a cost impact, either the ITS Standards Test has to be re-scoped, or the ATLAS project has to be re-scoped.

8. Evaluation of Benefits

The project agrees to participate in Evaluation of Benefits as described under Section 3.4 of the Guidance.

Each of the projects described in Sections 2 and 3 will be evaluated, either by ATLAS personnel (self-evaluation) or by third parties. These evaluations will address key aspects such as

- Beneficial and detrimental impacts to transportation management and traffic flow
- System and subsystem performance
- Consistency with the National and Regional ITS Architectures
- Acceptance by the users
- Institutional issues and concerns

Local Evaluation Reports will be developed for each of the projects. The reports will document lessons learned, key aspects of the projects, project outcomes and impacts. The Local Evaluation Report will address the following issues identified with an "X" (identify at least two):

X Evaluate the institutional issues associated with achieving cooperation among public sector agencies, and document how they were overcome.

X Provide a brief lessons learned report on the technical and institutional issues encountered in integrating ITS components.

_ Provide an evaluation report on the lessons learned in employing innovative financing or procurement and/or public-private partnering techniques.

_ Produce a lessons learned report on the experiences, challenges and approaches used in achieving consistency with the National ITS Architecture and/or implementation of ITS standards.

_ Produce a case study on the planning process used to achieve integration into an approved plan and program developed under an area-wide (statewide and/or metropolitan) planning process which also complies with applicable state air quality implementation plans

_ Provide the appropriate metropolitan planning process with data generated by ITS technologies and services, and provide a report on plans or intentions for archiving the data and using it.

Furthermore, ATLAS will request its Technical Advisory Committee to form an *evaluation planning and review (EPR) team*. The EPR team will meet periodically, in conjunction with TAC meetings, to ensure that the self and third-party evaluations are well planned, valid and mutually acceptable.

Cost accounting data will also be collected and documented. ATLAS is already a user of the ITS Evaluation website set up by FHWA through a contractor. (See www.its.dot.gov/eval/resourceguide/).

Included at this site are guidelines for the evaluations; ATLAS will follow applicable guidelines for the subprojects described in this proposal.

It is possible that FHWA, or a party assigned by them, may wish to conduct additional independent evaluations of the project outcomes. In that case, ATLAS agrees to participate in "Evaluation of Benefits" by FHWA, and will cooperate with the independent evaluators, and will participate in planning the evaluations and in review meetings – to ensure a successful implementation of the independent evaluations. However, this is contingent on (a) there is no cost impact for ATLAS, and (b) no cost impact for its partners and subcontracts. If a ATLAS project is selected and there is a cost impact, then the ATLAS project has to be re-scoped, perhaps by eliminating the third-party evaluations (see e.g., Tasks A9 and B11).

Each of the subprojects described in this proposal will have its own evaluation plan, and the contact person will be the lead principal investigator of the subproject. Since the overall ATLAS-ITS Phase IV is managed by Dr. Pitu Mirchandani, he will be the liaison for the evaluations of the subprojects. Contact particulars are:

Evaluation Contact: Pitu Mirchandani
ATLAS Center
Systems and Industrial Engineering Department
The University of Arizona
Phone: (520) 621 2990
Fax: (520) 621 6555
E-mail: pitu@sie.arizona.edu

SCHEDULE

9. Start Date

It is anticipated that the Project will start on November 15, 2001

10. Expected Completion Date

The overall completion date is November 15, 2004.

11. Milestones

The conduct of the five projects will be staggered over a three-year period, as per schedule shown in Exhibit 1. There will be a final report for each of the projects and a final report for the overall program described in this proposal. In addition, there will be working papers, to serve as interim reports, for projects C, D, and E.

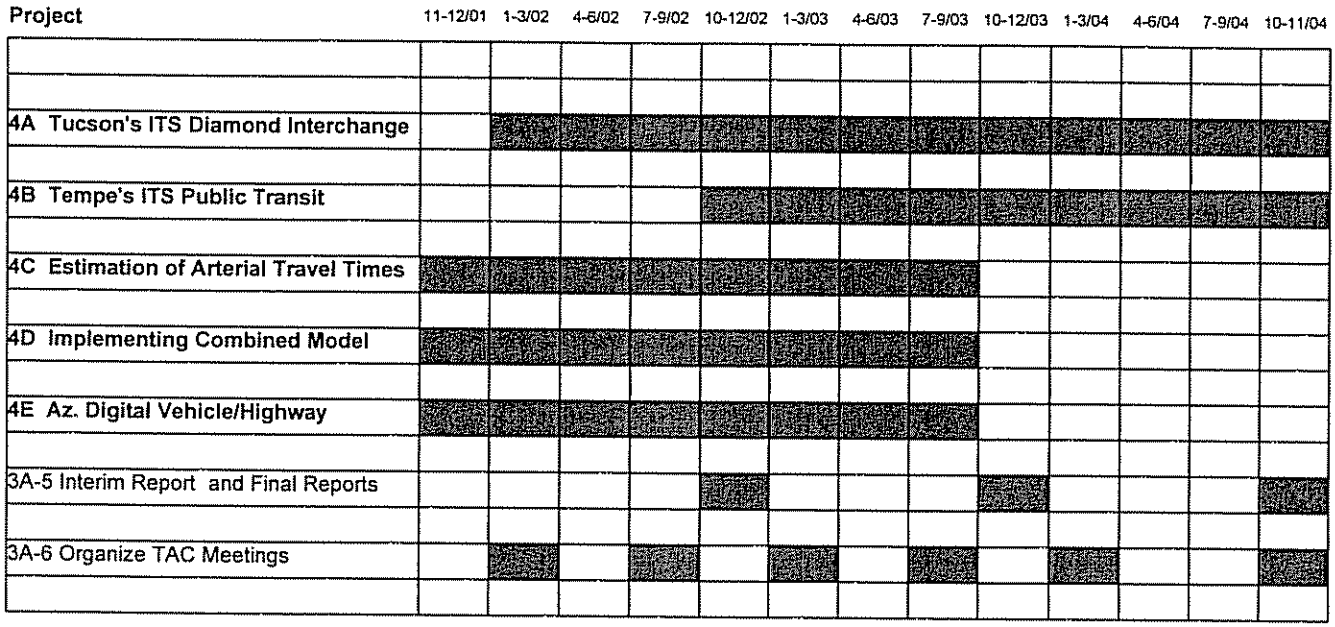

EXHIBIT 1: Project Schedule and Deliverables

FINANCIAL PLAN

12. Non-Federally Derived Funding Sources

Congressionally Designated Amount: $ 793,615

Amount Used for Integration Activities: $ 590,086

Amount Used for Rural Infrastructure Deployment: $ 203,529

20% Minimum Match Amount: $ 317,446

A minimum 20% of the total cost of the project must be from non-Federally derived funding sources, as statutorily required, and must consist of either cash, substantial equipment or facilities contributions that are wholly utilized as an integral part of the project, or personnel services dedicated full-time to the proposed integrated deployment for a substantial period, as long as such personnel are not otherwise supported with Federal funds.

Identify Non-Federal Funding Source	**Identify Type of Funds** (cash, equipment or facilities, or full-time personnel services)	**Identify Major: (1) Integration Activities or (2) Rural Infrastructure Deployment Supported with These Funds**	**Specify ($)**
University of Arizona	Cash and personnel	Both, (in all projects)	$ 171,390
University of Illinois	Personnel	(1), for Project 4D	$ 41,401
Maricopa County DOT	Cash	(1), for Project 4C	$ 40,000
City of Tucson	Equipment /Installation	(1), for Project 4A	$ 32,964
City of Tempe	Equipment /Installation	(1), for Project 4B	$ 31,691

Note: Personnel identified for 20% Match include Professor Mirchandani, ATLAS Center Director, and other ATLAS faculty who will have major responsibilities in project management and development of methods and technologies that will be integrated and/or deployed. Also included is University of Illinois' David Boyce's time on Project 4D.

13. Other Funding Sources

Remaining 30% Match Amount: (at least $ 476,169)
A minimum of 30% of the total cost of the Project may come from a variety of funding sources and may include the value of Federally-supported projects directly associated with the proposed integration project.

Identify Funding Source	**Identify Type of Funds** (cash, equipment or facilities, or personnel services)	**Identify Major: (1) Integration Activities, (2) Rural Infrastructure Deployment, or (3) Infrastructure Deployment Supporting Integration Supported with These Funds**	**Specify Amount of Funding** ($)
City of Tucson/ADOT	Equipment/Installation	(1), for Project 4A	$ 167,036
City of Tempe	Equipment/Installation	(1), for Project 4B	$ 143,309
BTS, (USDOT)	Project Funding	(1), for Project 4C	$ 50,000
ITI Consortium	Equipment and personnel	(2), for Project 4E	$ 180,000

Note: More than the required $ 476,169 is matched here. The total is $ 540,345.

The overall budget for all projects, including breakdown of personnel and operations categories, in administrative and technical functions, is given as Exhibit 2. Exhibit 3 details the cost matching for each subproject. Exhibits 4-8 provide details for each subproject that make up the overall budget of Exhibit 2.

EXHIBIT 2

ATLAS Phase IV Overall Budget with Cost share

SUBPROJECT NO. & NAME	Project 4A: Tucson ITS Diamond			Project 4B: Tempe ITS Bus Project			Project 4C: Travel Time Estimation*				Project 4D: Implementing Combined Model			Project 4E: Az Digital Highway/Vehicle			TOTAL	TOTAL	
BUDGET CATEGORY	FHWA/ADOT	Other cost-share	UA Cost-share	FHWA/ADOT	Other Cost-share	UA Cost-share	FHWA/ADOT	BTS cost-share	ADOT cost-share	UA Cost-share	FHWA/ADOT	UIC Cost-share	UA Cost-share	FHWA/ADOT	ITI cost-share	UA Cost-share	FHWA/ADOT	Cost share	TOTAL
ADMINISTRATIVE:																			
Project Management			18,000	0		26,000				3,200	2,000	3,300	3,300			12,000		66,800	67,800
Business Manager	7,000			7,000			900	600	300		1,200			7,000			23,100	900	24,000
TOTAL DIRECT LABOR	7,000		18,000	7,000		26,000	900	600	300	3,200	3,200	3,300	3,300	7,000		12,000	25,100	66,700	91,800
ERE																		0	
Faculty			3,420			4,940	0	0	0	608	380	797	627			2,280		12,672	13,052
Staff	1,512			1,512			194	130	65	0	259	0	0	1,512			4,990	194	5,184
TOTAL ERE	1,512		3,420	1,512		4,940	194	130	65	608	639	797	627	1,512		2,280	5,370	12,867	18,236
Operations & Office Supplies	2,000			2,000			1,651				1,000			2,000			8,651	0	8,651
Travel	1,000			2,000			1,000				500			2,000			6,500	0	6,500
TOTAL ADMINISTRATIVE	11,512		21,420	12,512		30,940	3,745	730	365	3,808	6,339	4,097	3,927	12,512		14,280	45,621	79,567	126,187
TECHNICAL:																			
Investigators																			
Mark Hickman							6,000	0	2,000	5,440	5,000		3,300				11,000	10,740	21,740
Judy Jin							6,000	5,140	3,000	6,160							6,000	14,300	20,300
Pitu Mirchandani	18,000			18,000			13,500	0	2,000	3,200	3,300			15,000		6,000	67,800	11,200	79,000
Feiyue Wang														23,000		6,000	23,000	6,000	29,000
David Boyce											14,500	18,093						18,093	
TOTAL FACULTY	18,000			18,000			25,500	5,140	7,000	14,800	22,800	18,093	3,300	38,000		12,000	122,300	60,333	182,633
Students	67,200		8,000	60,000		16,000	49,000	21,000	22,000	8,000	12,500		4,300	95,000			283,700	79,300	363,000
TOTAL DIRECT LABOR	85,200		8,000	78,000		16,000	74,500	26,140	29,000	22,800	35,300	18,093	7,600	133,000		12,000	406,000	139,633	545,633
ERE																			
Faculty	3,420			3,420			4,845	977	1,330	2,812	4,332	4,371	627	7,220		2,280	23,237	12,397	35,634
Students	4,704		560	4,200		1,120	3,430	1,470	1,540	560	875	0	301	6,650			19,859	6,551	26,410
TOTAL ERE	8,124		560	7,620		1,120	8,275	2,447	2,870	3,372	5,207	4,371	928	13,870		2,280	43,096	17,948	61,044
Operations	2,600			2,600			1,000	1,340	548		983			2,600			9,783	1,888	11,671
Subcontracts	55,000			80,000													136,000		135,000
Travel	5,000			5,000			2,000	1,687	2,000		1,600			5,000			18,600	3,687	22,287
Equipment	10,000			10,000			2,000	1,000						10,000			32,000	1,000	33,000
TOTAL TECHNICAL	166,924		8,560	183,220		17,120	97,775	32,614	34,418	26,172	43,090	22,464	8,528	164,470		14,280	644,479	164,156	808,635
TOTAL ADM & TECH	177,436		29,980	195,732		48,060	91,520	33,343	34,783	29,980	48,429	26,562	12,455	176,982		28,560	690,100	243,723	933,822
Indirect (15%)	26,616		4,497	29,360		7,209	13,728	16,657	5,217	4,497	7,264	14,840	1,868	26,547		4,284	103,616	59,069	162,684
Other (non-UA) Cost share (details in text and individual budgets for subprojects)																			
City of Tempe					175,000														
City of Tucson/ADOT		200,000																176,000	
ITI Consortium																		200,000	
															180,000			180,000	
GRAND TOTAL	204,051	200,000	34,477	225,092	175,000	55,269	105,248	50,000	40,000	34,477	55,694	41,401	14,323	203,529	180,000	32,844	793,615	857,792	1,651,406

EXHIBIT 3

Summary of ATLAS IV Budget and Funding

BUDGET CATEGORY	FHWA/ADOT	UA Cost Share	Other Cost share	Total
Subproject 4A	204,051	34,477	200,000	438,528
Subproject 4B	225,092	55,269	175,000	455,361
Subproject 4C	105,249	34,477	90,000	229,726
Subproject 4D	55,694	14,323	41,401	111,418
Subproject 4E	203,529	32,844	180,000	416,373
Total Project Cost	**793,615**	**171,390**	**686,401**	**1,651,406**
20% Non-Federal Match Req. ($ 318,145)				
Subproject 4A		34,477	32,964 [1]	
Subproject 4B		55,269	31,691 [2]	
Subproject 4C		34,477	40,000 [3]	
Subproject 4D		14,323	41,401 [4]	
Subproject 4E		32,844		
	317,446	**171,390**	**146,056**	
Footnotes				
[1]	City of Tucson, implementation of video detection and TS2 Cabinet			
[2]	City of Tempe, equipping buses and AVL system			
[3]	McDOT funding (cash)			
[4]	University of Illinois at Chicago support for David Boyce			
Other Cost Match Req. : At least 30% (at least $477,218)				
Subproject 4A			167,036 [5]	
Subproject 4B			143,309 [6]	
Subproject 4C			50,000 [7]	
Subproject 4D				
Subproject 4E			180,000 [8]	
Total	**540,345**		**540,345**	
Footnotes				
[5]	Federal and Tucson's contribution for design/implementation ITS infrastructure			
[6]	Tempe's implementation of communication and transit management software			
[3]	Federal funding from BTS			
[8]	Includes ITI's and consortium contribution towards the project			

EXHIBIT 4

SUBPROJECT N0. & NAME	Project 4A: Tucson ITS Diamond		
BUDGET CATEGORY	FHWA/ADOT	Other cost-share	UA Cost-share
ADMINISTRATIVE:			
Project Management			18,000
Business Manager	7,000		
TOTAL DIRECT LABOR	7,000		18,000
ERE			
Faculty			3,420
Staff	1,512		
TOTAL ERE	1,512		3,420
Operations & Office Supplies	2,000		
Travel	1,000		
TOTAL ADMINISTRATIVE	**11,512**		**21,420**
TECHNICAL:			
Investigators			
Pitu Mirchandani	18,000		
Research Assistants	67,200		8,000
TOTAL DIRECT LABOR	85,200		8,000
ERE			
Faculty	3,420		
Research Assistants	4,704		560
TOTAL ERE	8,124		560
Operations	2,600		
Subcontracts	55,000		
Travel	5,000		
Equipment	10,000		
TOTAL TECHNICAL	**165,924**		**8,560**
TOTAL ADM & TECH	**177,436**		**29,980**
Indirect (15%)	**26,615**		**4,497**
Non-Cash, Non-UA Cost-share:			
City of Tucson/ADOT		**200,000**	
GRAND TOTAL	**204,051**	**200,000**	**34,477**

City of Tucson Cost Share: Costs associated with the Video Detection and other instrumentation at the interchange and the implementation of ITS elements in the design of interchange (see attached letter)

Uof A Cost Share: Project Management by PI, (who will also be the technical manager), as well as student research assistant (who will be more than 50% on the project).

EXHIBIT 5

BUDGET CATEGORY	FHWA/ADOT	Other Cost-share	UA Cost-share
ADMINISTRATIVE:			
Project Management	0		26,000
Business Manager	7,000		
TOTAL DIRECT LABOR	7,000		26,000
ERE			
Faculty			4,940
Staff	1,512		
TOTAL ERE	1,512		4,940
Operations & Office Supplies	2,000		
Travel	2,000		
TOTAL ADMINISTRATIVE	**12,512**		**30,940**
TECHNICAL:			
Investigators			
Pitu Mirchandani	18,000		
Research Assistants	60,000		16,000
TOTAL DIRECT LABOR	78,000		16,000
ERE			
Faculty	3,420		
Research Assistants	4,200		1,120
TOTAL ERE	7,620		1,120
Operations	2,600		
Subcontracts	80,000		
Travel	5,000		
Equipment	10,000		
TOTAL TECHNICAL	**183,220**		**17,120**
TOTAL ADM & TECH	**195,732**		**48,060**
Indirect (15%)	**29,360**		**7,209**
Non-Cash, Non-UA Cost-share:			
City of Tempe		**175,000**	
GRAND TOTAL	**225,092**	**175,000**	**55,269**

City of Tempe Cost Share: Costs associated with the Design of Communication, Instrumentation of Buses and operation of the ITS elements (see attached letter)

Uof A Cost Share: Project Management by PI, (who will also be the technical manager); as well as a student research assistant (who will be more than 50% on the project).

EXHIBIT 6

SUBPROJECT N0. & NAME	Project 4C: Travel Time Estimation*			
BUDGET CATEGORY	FHWA/ADOT	BTS cost-share	McDOT cost-share	UA Cost-share
ADMINISTRATIVE:				
Project Management				3,200
Business Manager	900	600	300	
TOTAL DIRECT LABOR	900	600	300	3,200
ERE				
Faculty	0	0	0	608
Staff	194	130	65	0
TOTAL ERE	194	130	65	608
Operations & Office Supplies	1,651			
Travel	1,000			
TOTAL ADMINISTRATIVE	**3,745**	**730**	**365**	**3,808**
TECHNICAL:				
Investigators				
Mark Hickman	6,000	0	2,000	5,440
Judy Jin	6,000	5,140	3,000	6,160
Pitu Mirchandani	13,500	0	2,000	3,200
TOTAL FACULTY	25,500	5,140	7,000	14,800
Research Assistants	49,000	21,000	22,000	8,000
TOTAL DIRECT LABOR	74,500	26,140	29,000	22,800
ERE				
Faculty	4,845	977	1,330	2,812
Research Assistants	3,430	1,470	1,540	560
TOTAL ERE	8,275	2,447	2,870	3,372
Operations	1,000	1,340	548	
Travel	2,000	1,687	2,000	
Equipment	2,000	1,000		
TOTAL TECHNICAL	**87,775**	**32,614**	**34,418**	**26,172**
TOTAL ADM & TECH	**91,520**	**33,343**	**34,783**	**29,980**
Indirect (ADOT,McDOT:15%; BTS:51.5%)	**13,728**	**16,657**	**5,217**	**4,497**
GRAND TOTAL	**105,248**	**50,000**	**40,000**	**34,477**

BTS Cost Share: Funding for support of PI and two research assistants, plus travel and operations

McDOT Cost Share: Funding for support of investigators and one student RA (in-kind cost share not shown

Uof A Cost Share: Release time for key investigators plus student research assistant support

EXHIBIT 7

SUBPROJECT N0. & NAME	Project 4D: Implementing Combined Model		
BUDGET CATEGORY	FHWA/ADOT	UIC	UA Cost-share
ADMINISTRATIVE:			
Project Management	2,000	3,300	3,300
Business Manager	1,200		
TOTAL DIRECT LABOR	3,200	3,300	3,300
ERE			
Faculty	380	797	627
Staff	259		
TOTAL ERE	639	797	627
Operations & Office Supplies	1,000		
Travel	500		
TOTAL ADMINISTRATIVE	**5,339**	**4,097**	**3,927**
TECHNICAL:			
Investigators			
David Boyce	14,500	18,093	
Mark Hickman	5,000		3,300
Pitu Mirchandani	3,300		
TOTAL FACULTY	22,800	18,093	3,300
Research Assistants	12,500		4,300
TOTAL DIRECT LABOR	35,300	18,093	7,600
ERE			
Faculty	4,332	4,371	627
Research Assistants	875	0	301
TOTAL ERE	5,207	4,371	928
Operations	983		
Subcontracts			
Travel	1,600		
Equipment			
TOTAL TECHNICAL	**43,090**	**22,464**	**8,528**
TOTAL ADM & TECH	**48,429**	**26,562**	**12,455**
Indirect (ADOT/UA:15%, UIC: 55.87%)	**7,264**	**14,840**	**1,868**
GRAND TOTAL	**55,694**	**41,401**	**14,323**

University of Illinois (UIC) Cost Share: Prof. David Boyce will be assigned to ATLAS for three months to be th investigator and will interact with ATLAS and PAG personnel.

Uof A Cost Share. Drs. Hickman and Mirchandani will assist in project management and will also contribute with technical expertise. Also student RA support.

EXHIBIT 8

SUBPROJECT N0. & NAME	Project 4E: Az Digital Highway/Vehicle		
BUDGET CATEGORY	FHWA/ADOT	ITI	UA Cost-share
ADMINISTRATIVE:			
Project Management			12,000
Business Manager	7,000		
TOTAL DIRECT LABOR	7,000		12,000
ERE			
Faculty			2,280
Staff	1,512		
TOTAL ERE	1,512		2,280
Operations & Office Supplies	2,000		
Travel	2,000		
TOTAL ADMINISTRATIVE	**12,512**		**14,280**
TECHNICAL:			
Investigators			
Dr. Pitu Mirchandani	15,000		6,000
Dr. Feiyue Wang	23,000		6,000
Research Assistants	95,000		
TOTAL DIRECT LABOR	133,000		12,000
ERE			
Faculty	7,220		2,280
Research Assistants	6,650		
TOTAL ERE	13,870		2,280
Operations	2,600		
Subcontracts			
Travel	5,000		
Equipment	10,000		
TOTAL TECHNICAL	**164,470**		**14,280**
TOTAL ADM & TECH	**176,982**		**28,560**
Indirect (15%)	**26,547**		**4,284**
Non-Cash, Non-UA Cost-share:			
ITI Consortium		**180,000**	
GRAND TOTAL	**203,529**	**180,000**	**32,844**

ITI Consortium Cost Share: Costs associated with vehicle and instrumentation, consortium project management and mapping subcontracts (see attached letter)

Uof A Cost Share: Project Management by PI, (who will also be the technical manager); as well as a student research assistant (who will be more than 50% on the project)

PARTICIPATING AGENCIES AND ORGANIZATIONS

14. Project Participants and Roles and Responsibilities

Lead Agency	The University of Arizona
Roles and Responsibilities	Direct and manage the ATLAS Projects 4A, 4B, 4C, 4D, and 4E
Contact	Dr. Pitu B. Mirchandani

Participating Agency	Arizona Department of Transportation
Roles and Responsibilities	Assist in ATLAS project administration and in the integration efforts for Projects 4A and 4E
Contact	To be determined
Participating Agency	City of Tucson
Roles and Responsibilities	Assist in the integration for Project 4A and continued long-term operations and maintenance of the traffic control system.
Contact	Dr. Richard Nassi
Participating Agency	City of Tempe
Roles and Responsibilities	Assist in the integration efforts for Project 4B and continued long-term operations and maintenance of the traffic control system with bus priority.
Contact	Jim Decker

The partners/collaborators on this ATLAS team have a proven record of cooperation. They have worked together on several traffic management projects. In addition, all of the project team members are committed to improving traffic conditions, enhancing the benefits of mobility, and decreasing traffic congestion and its detrimental impacts. Appropriate public agencies, interest groups and stakeholders will be involved in the integration and deployment activities. Appended with this proposal are letters of commitment and support from some of our partners/collaborators, namely, the City of Tucson, the City of Tempe, Maricopa County Department of Transportation and Intelligent Technologies International, Inc.